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ON THE LIFE HISTORY OF AUTOLYTUS COR-
NUTUS AND ALTERNATE GENERATION
IN ANNELIDS.

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THE claim for the presence of an alternation of generation in annelids owes its origin chiefly to the results obtained in study of the family of syllidians by the earlier authors, Milne-Edwards, Savigny, De Quatrefages, Krohn, and more recently by A. Agassiz. What subsequent proofs of the presence of this condition in annelids have been presented still find their strongest support in the phenomena observed in a division of this family, that of *Autolytus*.

In forms of *Autolytus*, like *Autolytus cornutus*, described by Agassiz, after the young and so-called asexual animal has attained a certain length, a new head is developed on the fourteenth setigerous segment, and in this way the individual becomes divided into what is known as the parent stock, including the original head with its segments, and the bud or stolon, including the new head with the remaining segments. The stolon contains the maturing sexual products, and after these reach a certain stage of maturity it separates from the

parent stock and becomes free-swimming. The parent stock, as soon as the stolon is separated, regenerates the lost segments and in like manner develops a second and possibly a third or fourth bud. (In some forms of *Autolytus* (*A. varians*) the regeneration of new segments takes place before the shedding of the mature stolon, and thus a chain consisting of, at times, as many as eight stolons in different stages of development, becomes attached to the parent stock. In *Autolytus cornutus*, however, as in *Proceræa*, the stolon matures and becomes separated before an addition of new segments takes place, so that the parent stock of this form never bears more than a single stolon at a time.) During the process of separation the stolon undergoes such changes as are of service to it in the change of its life from among hydroids to that of surface swimming, the most conspicuous of which are the modification of the parapodia and the development of the swimming setæ. The sexual differences, as will be seen in comparing the free stolons, are also very conspicuous and appear quite early in the development of the stolon.

The free-swimming male stolon of an *Autolytus* was first described by Oersted, in 1843, as a new species of annelid to which he gave the name *Polybostricus*, while the free female stolon of another species (*Autolytus prolifera*) was similarly described by J. Müller, in 1853, under the name of *Sacconereis*. It was not until 1862, however, that Agassiz, in observing the separation of the stolon in *Autolytus cornutus*, demonstrated for certain the relation of the parent stock and stolons.

Alternate generation for annelids was first suggested by De Quatrefages in 1843, after observing a part of the budding process in a syllid (*Syllis monilaire*) previously described by Savigny; later again by Krohn, in 1852, for *Syllis prolifera*, but the first complete description of the process was given by Agassiz, in 1862, in a paper entitled "On Alternate Generation of Annelids and the Embryology of *Autolytus Cornutus*." The development of the stolons of this syllid and their subsequent separation he followed stage by stage, and established the identity of the separately described *Polybostricus* and *Sacconereis* without a doubt. The stolons he described as sexual indi-

viduals which have been separated from the parent stock by a process similar to that of fission. The parent stock he regarded as distinctly asexual and as reproducing only by the separation and budding out of sexual stolons. A diagram of Agassiz's description of the cycle of generation would therefore be as follows :

$$\begin{array}{l} \text{Stolon} = \times < \text{Eggs} \\ \text{Egg} = \text{Parent Stock} \\ \text{Stolon} = \times < \text{Eggs} \end{array}$$

In this wise he attributed to *Autolytus cornutus* a distinct alternation of generation—in reality the only accurate alternate generation ever described for any annelid, and his original diagram of *Autolytus cornutus* still stands in some of our recent zoological text-books as a classical figure for the verification of alternation of generation in annelids.

The asexual condition of the parent stock is, however, not as constant as was supposed by Agassiz. In many of the specimens examined, particularly in individuals from which a first stolon has been separated, sexual products appear in the twelfth and thirteenth and even at times in the eleventh segment of the parent stock. At the time when the first stolon, *i.e.*, the stolon which originally formed a part of the body of the parent stock, becomes filled with sexual products none of the segments of the parent stock give any indication of the presence of reproductive products. In older individuals, however, in which apparently after a second or possibly a third stolon has been separated, I have found reproductive products in some stage of development in a large number of the specimens examined. Of such parent stocks found with reproductive products, by far the greater number were females, and of these I have been able to obtain individuals in which the ova had attained a size almost equal to that of mature ova. The different stages in the development of the sexual products I have been able to follow more successfully in a near relative of *Autolytus*, *Proceræa ornata*, the budding of which is in all respects similar to that of *Autolytus cornutus*. Of this species I have been able to find female specimens of parent stocks with ova in all stages of development up to the time when the ova are discharged from

the body. The egg-sac, which it may be assumed also appears in these specimens, I have not been able to observe.

The external appearances of a parent stock with reproductive products in the stages of development in which I have been able to observe them differ very little from a parent stock in which no such products are as yet present. Occasionally I have found that the anterior eyes appear somewhat larger, but no modifications of the parapodia, such as would indicate the epitokal condition so common in other syllidians, were observed. In all sexually mature parent stocks of *Proceræa* I have found a third pair of eyes near the inner insertion of the palps. These are present as mere pigment spots in very young individuals of both *Proceræa* and *Autolytus cornutus*, but as a rule disappear or remain very inconspicuous in the adult. In several of the specimens in which the ova were nearest mature, conspicuous ventrally directed lenses were present. A similar development of this third pair of eyes I have observed in the epitokal syllid *Odontosyllis*, taken at a time when the eggs have reached complete maturity; so that the appearance of this pair of eyes in the parent stock of *Autolytus* at this time might, I think, be looked upon as partaking of the epitokal condition in other syllidians.

The percentage of parent stocks found with sexual products is by all odds too great to be looked upon as merely accidental. In a number of individuals examined, from all of which the stolons had recently been separated, and in which regeneration of segments was taking place (in this way eliminating as far as possible such individuals as are developing a first stolon), reproductive products were found to be present in as many as five out of twenty specimens examined for *Autolytus cornutus*, and in as many as six and sometimes seven out of twenty specimens of *Proceræa* examined. The stages of development of the reproductive products varied from early stages in which the presence of sexual cells could only be determined by the examination of sections to the more mature ova already referred to. By eliminating the apparently less mature individuals and selecting only such as would indicate by their size and general appearance that at least a second stolon had been separated, as many as ten to twelve out of twenty specimens were found to contain sexual

products. Such conditions would strongly indicate that the presence of reproductive products toward the close of the phenomenon of budding is a constant stage in the life history of these syllids.

The life history of *Autolytus cornutus* would, therefore, consist in: (1) The development, from the egg, of the parent stock; (2) the development of sexual products in segments posterior to the thirteenth setigerous segment, the development of a head on the fourteenth, and the separation of these segments for the formation of the free-swimming stolons, *Polybostrius* (♂) and *Sacconereis* (♀); (3) regeneration of the lost segments and the formation in this way of a second and possibly a third or fourth stolon; (4) finally, the development in the parent stock of sexual products and the conversion of it into a sexual individual (Fig. 5). While the sexual products are forming, the regeneration of lost segments is still taking place, but in none of the specimens found had this new growth gone farther than the formation of a small bud, consisting of no more than eight or ten distinct segments.

As compared with a diagram of the cycle of generation as described by Agassiz, we would then have:

$$\begin{aligned} \text{Stolon} &= \times < \text{Eggs} \\ \text{Eggs} = \text{Parent Stock} &= \times < \text{Eggs} \\ \text{Stolon} &= \times < \text{Eggs} \end{aligned}$$

This would therefore be, not a sexual generation alternating with an asexual, but at most no more than a sexual dimorphism—a sexual individual budding off sexual stolons, and as its own sexual products mature, partaking more or less of the epitokal form of other syllids and itself becoming sexual.

Alternate generation has also been claimed for chain-forming syllidians, as *Myrianide*; but the presence of reproductive products in the posterior segments of the parent stock is of so common occurrence that the existence of such a generation has already prior to this been disputed by St. Joseph and Malaquin.

Korschelt and Heider in their text-book of *Comparative Embryology*, in accordance with the papers of Krohn and Agassiz, describe this process as a true alternation of generation, and hold it as distinctly different from the fission in *Ctenodrillus*,

Protula, and Nais, in which all divided individuals are sexual and alike in all respects, and which, they assert, cannot be regarded as a true alternation of generation. They summarize the budding of Autolytus as "a process that is to be placed alongside that of strobilization in the Scyphomedusæ." The presence of reproductive products in the parent stock of Autolytus throws doubt upon this comparison, and it appears to me more plausible to place these forms alongside the processes described by Brooks for the Hydromedusæ (*Mem. Bost. Soc. Nat. Hist.*, Vol. III, No. 12). Particularly striking in this respect is the similarity in the life history of *Autolytus cornutus* to the life history of *Cunina octonaria*, which he gives in a diagram as follows:

$$\begin{array}{l} \text{Hydra} = \text{Medusa} \times < \text{Eggs} \\ \text{Egg} = \text{Planula} = \text{Actinula} = \text{Medusa} \times < \text{Eggs} \\ \text{Hydra} = \text{Medusa} \times < \text{Eggs} \end{array}$$

Here, according to Brooks, there is asexual multiplication without alternation of generation. Since in *Autolytus cornutus* and *Proceræa* the parent stock also becomes sexual, just as does the actinula, we would have, in the life history of these syllids, nothing more than the parent stock undergoing asexual multiplication, and forming stolons just as in the asexual multiplication of the actinula to form hydra. Taking the meaning of alternation of generation, as defined by Brooks in his work on the Hydromedusæ, as the commonly accepted one, — a definition which is also in accord with the descriptions given by Korschelt and Heider, — we would have in the syllids, for which a true alternation of generation has been claimed, no alternate generation at all, but simply a dimorphism resulting from an asexual multiplication of the parent stock.

Without taking into consideration the morphological value of the stolon it would appear more plausible, therefore, to regard stolonization in *Autolytus* as a process akin to that of fission in other annelids — unlike the fission in *Dero*, *Ælosoma*, and other forms where the divided individuals are identical in all respects, in that it has direct reference to the distribution of the sexual products, yet similar to these in that all the resulting divisions are in reality sexual individuals.

Another aspect of this question is, however, presented by the morphological characters of the stolon itself. In the process of its development the stolon *has* been provided with a head very similar in structure to that of the parent stock, and with eyes even larger and more advantageously placed than those of the parent stock. The alimentary canal, moreover, is in a state of degeneration; the crowding of the reproductive products, particularly in the female stolon, has greatly reduced its calibre, and to all appearances it has ceased to function. Organs for the prehension of food are absent, a mouth-opening being formed simply by a union of the broken intestinal wall with the hypodermis, and it is quite evident, by the changes that have taken place in the alimentary canal of the mature stolon, and also by the continuous absence of food particles within it, that the stolon in its free-swimming stages does not feed. The stolon would then in reality reduce itself to a series of segments, some of which, in the male, or a large number of which, in the female, are gorged with reproductive products and provided with organs fitted for the proper distribution of the reproductive products—a condition similar to, but, by virtue of a head formation, more advanced than that which has been described for the sexual fragmentation in the Palolo worm. While the stolon must, for want of a better expression, be regarded as a distinct individual, in connection with the problem of alternation of generation the morphological value of such a structure might well be questioned.

The existence of a true alternation of generation in annelids so long as it is supported alone by the phenomena presented by *Autolytus* seems to me far from being established, and it is doubtful if a more extended study of any of the syllidians would add more to this proof. The presence of reproductive products in even a smaller percentage of parent stocks than were found in *Autolytus cornutus* or *Proceræa* could still hardly be looked upon as of purely accidental occurrence. Instead of regarding the presence of such sexual products in the parent stock of *Autolytus* as accidental, it seems to me more plausible to regard it as the continuance of a more primitive condition in which the animal *in toto* assumed, at the ripening of the sexual

products, an epitokal form like that in *Eusyllis*, *Odontosyllis*, and *Exogone*, and stolonization as a secondary condition acquired for the purpose of a more perfect distribution of the sexual products. The complete epitokal changes in *Autolytus* have already been observed by Malaquin in *Autolytus lorgeferiens*, and described by him under the name of "epigamie," and it is very probable that a further study of the different species of *Autolytus* found along our coast would yield similar results. From our present knowledge it would appear that, as in *Autolytus cornutus*, the epitokal changes have been lost, or at least in greater or lesser part suppressed, in the parent stock of some syllids, and that in this way closely related forms of syllidians may exhibit sexual changes as various or more so than are shown in different species of *Nereis*; but it is very doubtful whether in any of our species the loss of sexual products has been so equally shared with these other changes as to leave a distinctly asexual parent stock.

The high development of the head of the stolon would form the strongest argument in favor of the distinct individuality of the stolon. Malaquin (*Recherches sur les Syllidiens*) has, however, already shown that the head of the stolon in different species of syllidians presents very different grades of development. In making this comparison he says: "L'individualisation du stolon diminue de plus en plus, au fur et à mesure qu'on suit la marche graduelle de ce phénomène. — autrement dit la tête qui marque pour ainsi dire le degré de perfectionnement de son individualité, se simplifie de plus en plus et arrive même à ne plus se former du tout." His figures, in which he compares the head of the stolon of *Haplosyllis hamata*, in the formation of which no development of a head takes place, with that of *Trypanosyllis*, in which a small head supplied with eyes is present, and, by different intermediate forms, with the complicated head structures of *Autolytus*, very clearly indicates, as had already been suggested by Huxley, that the stolon among syllids is not as distinctly individualized as would appear in observations on *Autolytus* by itself.

SOME NOTES ON REGENERATION AND REGULATION IN PLANARIANS.

FRANK R. LILLIE.

I. THE SOURCE OF MATERIAL OF NEW PARTS AND LIMITS OF SIZE.

MANY observers have noted the tendency of planarians kept without food to diminish in size. My attention was specially directed to this phenomenon by some experiments undertaken to test the effect of external conditions on the regeneration of *Planaria maculata*. I had already studied the effect of temperature on the regeneration of this form in conjunction with Mr. Knowlton.¹ I next undertook to test how far the chemical constitution of the medium affected the rate and form of regeneration. As an introduction to the systematic study of this subject, I made some experiments to determine whether any of the substances dissolved in the water of the habitat is necessary for regeneration. For this purpose I redistilled some of the ordinary distilled water of the laboratory, using flasks of Jena glass to get rid of the minute traces of copper found in water from copper stills. Permanganate of potash was dissolved in the water in the Jena flask to destroy traces of organic matter, and the distillate was again distilled in the same manner to insure the greatest possible degree of purity. The redistilled water thus obtained was carefully oxygenated by running a stream of air through it.

The pieces of planarians used for the experiments were washed in this water and then transferred to more of the same; the vessels (cleaned in strong acid) and water were changed frequently to get rid of any traces of bacterial growth. I soon found that under these circumstances regeneration went on as

¹ Lillie and Knowlton. The Effects of Temperature on the Development of Animals, *Zoöl. Bull.*, vol. i.

rapidly and as well as in tap water or the water of the habitat; thus demonstrating that the substances contained in these waters were not necessary for regeneration.

However, the decrease in size already mentioned was so rapid and marked as to appear to deserve special study. So I isolated a number of active planarians in the redistilled water, measured them, and kept them in a thermostat at temperatures that ranged from 20° to 27° C. The dishes and water were changed regularly and frequently, measurements of each individual being made at the same times. The table on the opposite page shows the history of these specimens; less than half of the actual measurements in this series are given.

It will be noted that the rate of decrease was not the same in all; in 2, for instance, it was much more rapid than in the others. This is probably due in part to greater activity of 2. Nor is the rate perfectly uniform in any given specimen, probably owing to variations in the temperature and in activity at different times.

The smallest specimen obtained (No. 5, after 43 days) was certainly less than one-hundredth the bulk of the original animal. Its length was one-fifteenth the original length, its width one-third the initial width, and if we suppose that its dorso-ventral diameter was reduced by only one-half, the bulk would be one-ninetieth of the original bulk. But there can be little doubt that its dorso-ventral diameter was reduced more than one-half.

Increase by fission was entirely stopped, but, on the other hand, the power of regeneration remained. Thus, when No. 5 had been reduced to less than one-half its original length, it was cut in two parts, and both regenerated completely, *although with constant diminution in bulk*. The same experiment succeeded in No. 3, after it had been starved to less than one-fourth its original length.

It is thus demonstrated that from a given individual one of less than one-hundredth the original bulk may be produced by appropriate means. This constitutes a criticism on those experiments that have been made to determine the limits of regeneration in planarians by direct operation. The possible

DAYS.	1.	2.	3.	4.	5.
1	7 × .7	7 × .5	10 × 1	6 × .5	9 × .75
5	7 × .7	5.5 × .5	7 × 1	6 × .5	8 × .75
12	6.5 × .5	4 × .33	6 × .66	Dead.	5 × .5
17	6 × .5	4 × .33	5 × .4		4 × .3
23	4 × .5	2.5 × .5	4.3 × .5		3.25 × .3 Cut in two.
25		Cut in two.			1.75 × .3 (head) 1.25 × .3 (tail)
27	3.7 × .4	1.25 × .3 (head) Partial regeneration. Died.	4 × .4		1.75 × .3 (head) 1.25 × .3 (tail) Partial regeneration.
33	3 × .4		3 × .4		1.4 × .3 (head) .9 × .3 (tail) Complete regeneration. Anterior piece died two days later.
40	2.3 × .4		2.7 × .4		.6 × .25
43	1.9 × .4 Cut in two. Parts died in two days.		2.25 × .4 Cut in two. Tail end, 1.1 × .4; regenerated in four days (partly). Head end, .9 × .4; regenerated very little new tissue.		.6 × .25 Lost by accident.

Table giving history of five planarians in distilled water. The vertical columns should be read separately. There is a slight discrepancy in the measurements of 2 and 3 for 17 and 23 days, no doubt due to an error in observation. The column to the left gives the number of days from the beginning of the experiment. The measurements, made after 17 days with the ocular micrometer, have all been reduced to millimeters.

limits of regeneration have been found by such experiments to be not much less than one-sixteenth of the bulk of the original animal. That a much lower limit has not been found is due partly to the extensive exposure of internal tissues along the cut surfaces, and partly (perhaps) to limitation of variety of tissue, but certainly not, it would appear, to deficient size.

Do all organs suffer equally in the reduction? It might be expected that the organs of reproduction would suffer first, as they do not contribute to the life of the individual; but the specimens used in the experiments were not sexually mature, so this point was not settled. The other systems of organs were reduced in apparently similar proportions. Thus the intestinal diverticula in 5 were reduced to five on each side, and the branches of the longitudinal nerves were apparently equally reduced.

Does the reduction affect chiefly the size or the number of the cells? A careful histological study would be necessary to answer this question in detail. Not having made this, all that I can say is that the branched pigment cells lying near the surface, that are readily visible under a low magnification, are reduced to very few, but their size is not noticeably affected.

Do the processes of reduction retrace the steps of normal growth and development? I think that this question must be answered in the affirmative. Certain it is that specimens reduced by starvation to a smaller size than just hatched specimens of the same species resemble these in their general proportions, the relatively greater breadth in proportion to length as compared with mature specimens, the smallness of the cephalic lobes, and in the small number of the intestinal diverticula and branches of the longitudinal nerves. It would be interesting to determine whether or not these artificial embryos, as they might be termed, could under favorable circumstances repeat the steps to the mature and fully grown condition from which they were reduced. I see no reason to doubt that this is possible.

In regeneration, under the circumstances of these experiments, two processes are taking place side by side; not only is new tissue being formed at the cut end, but the old tissues are

undergoing a translocation and partial redifferentiation to accommodate themselves to the new proportion that must be assumed. The new tissue at the cut end must be formed entirely from the old tissue, and the final result involves, therefore, an extensive working over of the old material. The original tissues, with constant losses, owing to destructive metabolism, are moulded into the form of a new individual. In trying to form a mental image of the forces at work in this complex rearrangement, one can think only of an "internal mould" (an expression of Buffon to which Professor Whitman has called my attention). No less remarkable is the maintenance of form in individuals that gradually waste away to one-hundredth part or less of their original bulk. Such individuals in all stages of reduction appear normal in all respects, physiologically as well as morphologically. They are active and exhibit perfectly normal reactions, showing no indications of sickness.

VASSAR COLLEGE, Jan. 4, 1900.

REMARKS ON THE SAN MARCOS SALAMANDER,
TYPHLOMOLGE RATHBUNI STEJNEGER.

W. W. NORMAN.¹

THROUGH the kindness of Mr. Leary, Superintendent of the U. S. Fish Hatchery at San Marcos, Texas, the Biological Laboratory of the University of Texas became the possessor of a small number of living salamanders that came up from subterranean waters 181 feet below the surface.

It has been the aim of the writer to study the habits of these strange animals, but through ill-luck only a single specimen is at the present writing alive, and the new arrivals at the well are becoming scarce.

For a systematic description of the animals the reader is referred to Stejneger's paper in the *Proc. of the U. S. Nat. Mus.*, Vol. XVIII, No. 1088.

A good idea of the animal may be had from the pictures accompanying this description.

The animals were kept in a large shallow basin of water containing water plants and some small organisms, such as water fleas.

Unless disturbed, the salamanders appear at all times either resting, or very slowly walking along. They move a few steps at a time, wait awhile, and go again. They have no particular pose when quiet except that they always rest on their four feet, holding themselves up from the bottom of the vessel, and frequently retain the position of the legs as if in the act of walking. Indeed, this position represents them as if suddenly

¹ A few years ago the late Professor Norman secured a number of specimens of the Texas cave salamander for me, to enable me to study the structure of their eyes. He himself intended to study the habits of the species. In September of 1899, Mrs. Norman placed his notes and photographs in my hands, and these are reproduced in this paper. The notes are just as he wrote them. I have added a few foot notes a few observations on living specimens kindly furnished me by Superintendent J. L. Leary, of San Marcos. — C. H. EIGENMANN.

stopped. This is beautifully shown in the photograph (Fig. 1) where the large animal has the left legs near each other, and the right far apart. If the vessel contains, for example, water-cress, they crawl in among the branches, stop as when walking on firm bottom, with the legs in such a position as fits easiest for gliding in among the twigs.

They are never seen to move faster than a slow, easy walk, except when disturbed by external stimuli.¹ Then one of three methods of locomotion may follow.

1. The walking speed may pass into a grotesque run by long strides and corresponding winds of the body; or, 2. This passes into a combined movement of legs and tail, the last act-

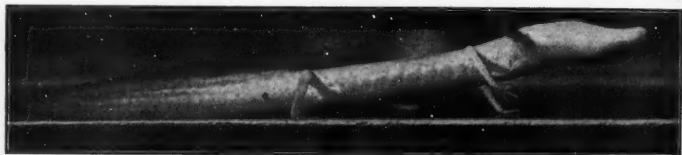


FIG. 1. — Photograph of a living salamander from the side.

ing as fin. 3. At its greatest speed the legs are laid lengthwise against the body, and the tail only used for locomotion.

The legs are exceedingly slender and weak. If the animal is placed on a table out of water, the body falls to the floor, and at best the animal may wriggle a few inches.

¹ The motion in water is, for the most part, slow and cautious, the movement of the long legs being apparently calculated to produce the least commotion in the water. The motion suggests that of a cat creeping upon its prey, or the elephantine progression of the snapping turtle. The feet are lifted high in walking, and the body is kept from the bottom by the full length of the fore arm and leg. In ordinary progression the body slopes from the nose to the tail, which drags (Fig. 1). The method of moving the limbs is as follows: Left hand and, when this is nearly ready to place, or usually when placed, the right foot. When the right foot is placed, then the right hand and then the left foot. As the hand of one side is not raised till the foot of the same side is placed, the enormous strides of the long-legged creature causes it to step on its hand or even beyond. Its natural gait is a deliberate progression by means of its feet with three feet usually on the ground. Any attempt at great rapidity by this means of locomotion results in a most undignified and futile wriggle. When going slowly the head is held sloping upward. When walking rapidly it is held sloping down, so that the snout is near the ground.

In water, however, the weight of the salamander is so little that the legs are amply strong for its locomotion. Professor Stejneger lost sight of this point when he guessed that the animal used its tail for locomotion and its legs as feelers, for he says: "Viewed in connection with the well-developed, finned swimming-tail, it can be safely assumed that these extraordinarily slender and elongated legs are not used for locomotion, and the conviction is irresistible that in the inky darkness of the subterranean waters they serve the animal as feelers."

No definite information has been obtained as to their habits in nature.

They show no reaction against light, either as a response by motion to the direction of the rays or to the quantity of light.

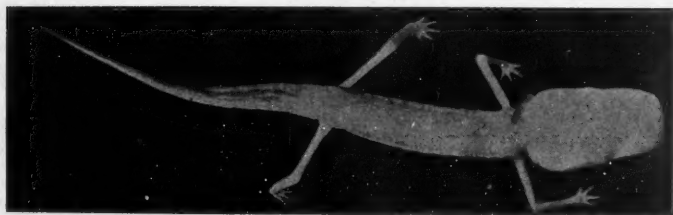


FIG. 2.—The same as Fig. 1, but from above.

If kept in a vessel, one-half of which is dark and the other half light, the animal is found about as much in one as the other, and on emerging into light from the dark half indicates in no way an awareness of the difference.

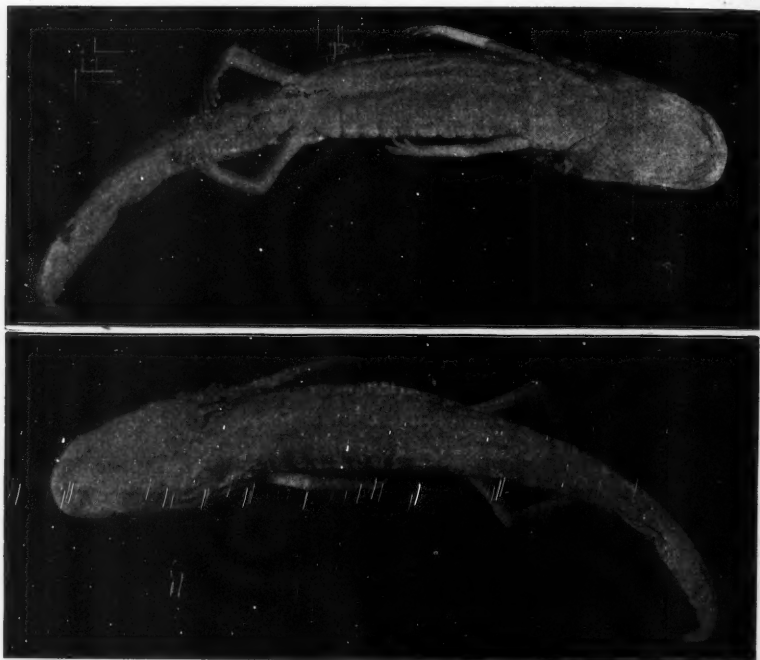
If in a tangle of plants, as watercress, they are found there about the same as in any other part of the vessel.

If they are headed against a current, the flowing water acts as stimulus urging them on. If the current strikes them from behind, they move more rapidly in the direction of flow.

The sense of touch is highly developed. There is, however, no experimental evidence that this is confined to any particular region. If the surface of the body is touched anywhere except at the blunt truncated snout, the animal responds at once by moving away. If the stimulus causes it to swim away, it may

go (say 12 or 16 inches) till it strikes the side of the vessel, after which it soon comes to a standstill.

If, however, it is struck say with the flat side of a scalpel handle sufficiently hard to move the entire animal even an inch backwards, it may not react, and this may often be repeated



FIGS. 3 and 4.

FIG. 3. — Dorsal surface of a salamander preserved in formalin.

FIG. 4. — Ventral surface of the same specimen.

before it reacts by moving away. A possible explanation of this is that in normal life it is every day striking itself against obstacles, especially the sides of the vessel (when in confinement).

The animal was kept in water about an inch deep, so that its head was near the surface. The waves of the water set going by a gentle puff of the breath act as a sure stimulus. It is exceedingly sensitive to any motion of the water.

But little evidence thus far shows in favor of a sense of smell. All attempts at feeding (except one) have been in vain. No attention was given to meat or other articles placed near it. Examination of a dead specimen showed chitinous remains of such Crustacea as Cyclops. To-day (April 18) I offered a salamander a small piece of the abdominal muscle of a crayfish. The bait was held by means of forceps about 5 mm. in front of the snout. The animal moved slightly forward, and the bait was kept at about the same distance. Suddenly it was snapped off and swallowed. The animal snapped off a second piece, but a third was refused.¹

¹ If a glass rod or other object is held a little to one side and in front of the animal, it will cautiously turn its head in the direction of the rod. If the latter is then made to describe an arc about the side of the salamander, the head will follow it with a continuous motion, expressive of the greatest caution, as far as it can be followed without moving any of the limbs. A sudden jar, produced by tapping the rod on the bottom of the aquarium at such a time, causes the salamander to jerk its head back and rear back on its limbs as far as it can. The same effect is produced if the rod is introduced too rapidly.

If a piece of crayfish tail is held by pincers in the fingers a short distance in front or to the side of the head of the salamander, there is the same cautious motion forward till the snout comes in contact with it. There is then a momentary hesitation, followed by a sudden snap and seizure.

The salamander may be pulled from side to side by the meat, after it has once secured a hold, without causing it to let go. All of its caution is apparently directed in approaching the food without disturbance. After it has secured a hold it will struggle to maintain it.

ON THE FREQUENCY OF ABNORMALITIES IN
CONNECTION WITH THE POSTCAVAL VEIN
AND ITS TRIBUTARIES IN THE DO-
MESTIC CAT (*FELIS DOMESTICA*).

C. F. W. McCLURE.

VARIATIONS of the postcaval vein and its tributaries are not of unusual occurrence, as is attested by the considerable literature on this subject. It is also generally conceded that these variations from the normal condition, to whatever cause they may be due, occur with greater frequency among domesticated animals than among those living in the wild state.

The object of the present paper is to emphasize especially the frequency with which such venous abnormalities may occur in a given number of individuals of the domestic cat (*Felis domestica*).

During the last five years the writer has observed that variations of the venous system, of some sort or another, occur with great frequency in the domestic cat; and in 1898-99 twenty-five cats dissected by students in the Princeton Laboratory were more carefully examined for such variations, with the following results:

In only ten of the twenty-five examined was the venous system apparently normal, while in 60 per cent, or in fifteen of the cats, thirty-three distinct abnormalities were met with in connection with the postcava and its tributaries. These, for descriptive purposes, have been grouped in the following table under five types.¹

The cats in which these abnormalities were found were chosen at random from those brought into the Laboratory and

¹ The figures represent the actual size of the preparations. The veins are in black and the arteries shaded. The numbering is the same for all of the figures. Many of the smaller arteries and veins have been omitted from the drawings.

were not, after dissection, selected on account of the abnormalities which they presented.

TYPES.		NUMBER OF CASES OBSERVED.
1. PERSISTENT POSTERIOR CARDINAL VEINS (<i>Vv. Cardinales post.</i>).		
(a) Left common iliac vein (<i>V. iliaca communis sinistra</i>) absent.		3
(b) Left common iliac vein (<i>V. iliaca communis sinistra</i>) present.		2
2. THE COMMON ILIAC VEINS (<i>V. iliaca communis sinistra</i> and <i>dextra</i>) UNITE TO FORM THE POSTCAVAL VEIN OPPOSITE THE MIDDLE OF THE SIXTH LUMBAR VERTEBRA, WHICH IS CONSIDERABLY CEPHALAD OF THE NORMAL POINT OF JUNCTION (opposite the posterior half of the seventh). The ilio-lumbar veins also, in each case, open into the right and left common iliacs and not into the common postcava, as is usually the case in the cat.		3
3. THE MIDDLE SACRAL VEIN (<i>V. sacralis media</i>) AND ITS RELATION TO THE VEINS OF THE PELVIC REGION.		
(a) Opens into the right common iliac vein (<i>V. iliaca communis dextra</i>)		4
(b) Opens into angle of union of two veins which join veins of right and left side, respectively		5
4. PERFORATION OF A VEIN BY :		
(a) An artery		6
(b) A nerve		3
5. DOUBLE VEINS WHERE ONE IS NORMALLY PRESENT		7

33

Description of the Venous Abnormalities.

I. PERSISTENT POSTERIOR CARDINAL VEINS (*Vv. Cardinales post.*). — Our knowledge of the development of the postcaval vein and our interpretation of the significance of the persistent double postcaval veins are largely due to Hochstetter,¹ who has shown that these veins are the homologues of the posterior cardinal veins of the embryo and of lower vertebrates.

Wilder and Gage² state that double postcaval veins occur in the domestic cat once in about ten cases. This percentage is somewhat less than that found by the writer (20 per cent), but perhaps represents more accurately the conditions commonly met with. In either case the percentage is extremely large when we consider how rarely this abnormality is met with in man.

¹ Hochstetter. *Anat. Anz.*, Bd. ii, *Morph. Jahrb.*, Bd. xiii, and *Anat. Anz.*, Bd. iii.

² *Anatomical Technology*, § 962.

Five cases of persistent posterior cardinal veins were met with by the writer in twenty-five cats examined. In three of these cases the left common iliac vein (*V. iliaca communis sinistra*) was absent, and in two it was present.

(a) PERSISTENT POSTERIOR CARDINAL VEINS. LEFT COMMON ILIAC VEIN (*V. iliaca communis sinistra*) ABSENT.

The three examples of this type were essentially the same in character and are well represented by Fig. 1.

In each instance the union of the two posterior cardinals (17) with the common postcaval vein (1) took place in the neighborhood of the kidneys. In two instances this union was opposite the third lumbar vertebra, and in one, opposite the fourth. In the former the right renal veins, single in one case and double in the other, opened into the right posterior cardinal; in the latter (Fig. 1) the right renal vein (7) opened into the common postcava (1).

In each instance, as in Fig. 1, the single left renal vein (7) opened into the left posterior cardinal (17).

The middle sacral vein (*V. sacralis media*), Fig. 2 (5), in each of these three cases, was connected with the posterior cardinal veins (17) in a characteristic manner. It opened into the angle of union of two veins which joined, respectively, the right and left posterior cardinal veins (17) at varying distances from the point of union of the external and internal iliac veins.

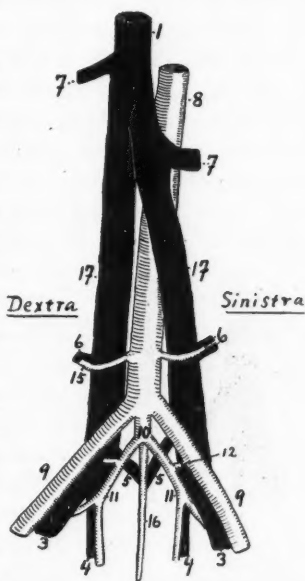


FIG. 1.—Princeton Morphological Museum, No. 601. Ventral aspect. *V. cardinalis dextra* and *sinistra* persistent. *V. iliaca communis sinistra* absent. 1. Postcava communis. 3. *V. iliaca externa*. 4. *V. iliaca interna*. 5. *V. sacralis media*. 6. *V. ilio-lumbalis*. 7. *V. renalis*. 8. Aorta. 9. *A. iliaca externa*. 10. *A. iliaca interna communis*. 11. *A. iliaca interna*. 12. *A. hypogastrica*. 15. *A. ilio-lumbalis*. 16. *A. sacralis media*. 17. *V. cardinalis post*.

(b) PERSISTENT POSTERIOR CARDINAL VEINS. LEFT COMMON ILIAC VEIN (*V. iliaca communis sinistra*) PRESENT.

Abnormalities of this type have been described as occurring in man, by Cruveilhier, von Gruber, Kollmann,¹ Lobstein, Nicolai, Quain, Wilde, and others.

Kollmann, with whom the writer is fully in accord, states as follows regarding the significance of this type of abnormality: "The significance of this condition can, according to my interpretation, only be as follows: Persistence of both cardinal veins, together with the connecting branch (*Verbindungsast*)."

By the "Connecting branch" is meant the vessel which is subsequently developed between the veins of the left hind extremity and the right posterior cardinal vein, in correlation with the appearance of the functional kidneys and the atrophy of the distal portion of the left posterior cardinal vein. This vessel becomes the left common iliac vein (*V. iliaca communis sinistra*).

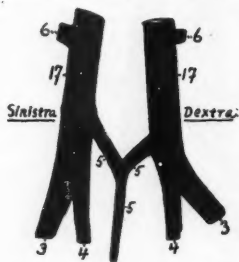


FIG. 2. — Dorsal aspect of Fig. 1. Arteries not indicated. *V. sacralis media* and its connection with *V. cardinalis dextra* and *sinistra*. For reference to numbers, see Fig. 1.

No instance was met with by the writer in which the "Connecting branch" ran in the reverse direction, that is, between the veins of the right hind extremity and the left posterior cardinal vein. Abnormalities of this

type, however, have been described by Timmermann, Walter,² Walsham, and others, as occurring in man.

Two cases were met with by the writer in which the posterior cardinal veins were persistent, together with the "Connecting branch."

In one (Fig. 3) the union of the two posterior cardinals (17) with the common postcava (1) was opposite the third lumbar vertebra; in the other (Fig. 4) this union was opposite the middle of the sixth lumbar vertebra.

In the first-mentioned case, represented by Fig. 3, where the

¹ Kollmann gives a very complete bibliography relating to this type of abnormality in Bd. viii of the *Anat. Anz.*, p. 113.

² See Kollmann's *Bibliography*.

two posterior cardinals unite with the common postcava opposite the third lumbar vertebra, the middle sacral vein (*V. sacralis media*) opens into the angle of union of two veins which, as in that case previously mentioned (Fig. 2), join, respectively,

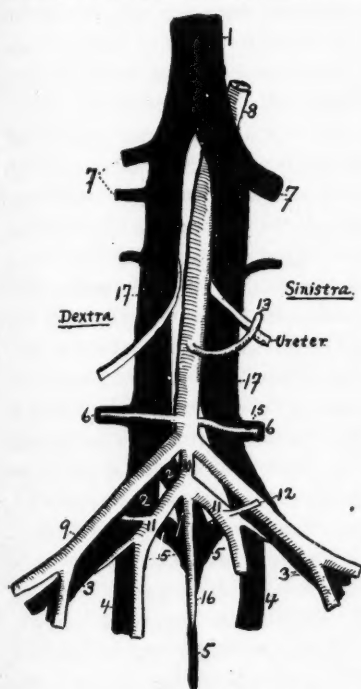


FIG. 3.—Princeton Morphological Museum, No. 603. Ventral aspect. *V. cardinalis dextra* and *sinistra* persistent. *V. iliaca communis sinistra* present. 2. *V. iliaca communis*. 13. *A. mesenterica post.* For remaining numbers, see Fig. 1.

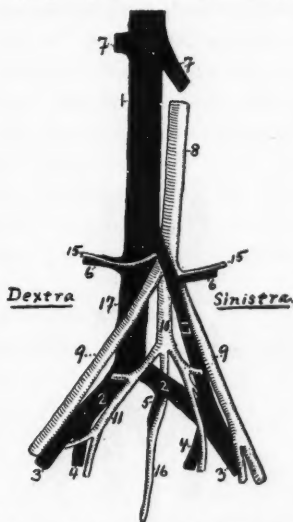


FIG. 4.—Princeton Morphological Museum, No. 603. Ventral aspect. *V. cardinalis sinistra* persistent, *ex parte*. *V. iliaca communis sinistra* present. 2. *V. iliaca communis*. For remaining numbers, see Fig. 1.

veins of the right and left side.

In addition to the above mode of union, which seems to be characteris-

tic for the middle sacral vein, whenever both posterior cardinals unite in the neighborhood of the kidneys, the middle sacral vein again opens into the right post-cardinal by an additional vessel. This third vessel, Figs. 3, 5 (2, sinistra), extends between that portion of the middle sacral vein which opens into the left posterior cardinal and the right posterior cardinal vein. It opens into the latter, opposite the point where

the right external iliac artery (9), Fig. 3, arises from the aorta. Although the connection of this third vessel with the middle sacral vein is abnormal, its relative position, and especially its connection with the right posterior cardinal at the above-mentioned point, lead the writer to the conclusion that it is the "Connecting branch" (Verbindungsast) which normally grows between the veins of the left hind extremity and the right posterior cardinal vein, in correlation with the appearance of the permanent kidneys and the atrophy of the distal portion of

the left posterior cardinal vein. This so-called "Connecting branch," under normal conditions, becomes the left common iliac vein (*V. iliaca communis sinistra*) and returns the blood from the left hind extremity to the postcaval vein. In this particular instance, however, the vein does not connect with the veins of the left hind extremity, but arises from the middle sacral vein by means of two radicles that soon become confluent, Fig. 5 (2, sinistra). The significance of this unusual connection will be spoken of in connection with the following topic.

The second case met with by the writer, in which the posterior cardinal veins persist, together with the "Connecting branch"

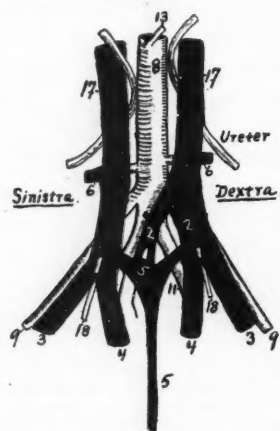


FIG. 5. — Dorsal aspect of Fig. 3. 2. *V. iliaca communis*. 13. *A. mesenterica post.* 18. *N. obturatorius*. For remaining numbers, see Fig. 1.

(*V. iliaca communis sinistra*), is represented by Fig. 4.

In this instance the persistent left posterior cardinal vein (17) unites with the corresponding vein of the right side, opposite the middle of the sixth lumbar vertebra, and not, as in the preceding case, in the region of the kidneys. The left posterior cardinal is also here of less importance physiologically, as is indicated by its relative size, than either the right posterior cardinal or the left common iliac vein (2). It is evident, therefore, that the bulk of the blood from the left hind extremity was carried to the common postcava, chiefly by the left common

iliac vein ("Connecting branch"), which is normal in every respect and has, as is usually the case in the cat, the middle sacral vein (5) opening into it. The ilio-lumbar veins (6), which, usually in the cat, open into the common postcava (1), in this instance (Fig. 4), open into separate vessels on the right and left side, respectively. That the vessel (17) on the left side, into which the ilio-lumbar vein (6) opens, is the left posterior cardinal vein and not the so-called "Connecting branch" is evidenced by the fact that the vein in question persists in common with the left common iliac ("Connecting branch"). In addition to this, the left posterior cardinal (17), in Fig. 4, lies ventrad of the aorta at the point where it unites with the corresponding vein of the opposite side, a circumstance characteristic of the left posterior cardinal vein.¹

The "Connecting branch" is not usually present when the left posterior cardinal persists. Its absence, under these conditions, is undoubtedly due to the circumstance that the left posterior cardinal vein, during all stages of development, continues to collect the blood from the left hind extremity, which makes uncalled for the development of a vessel to share in its function. When for some reason the "Connecting branch" does persist, together with the left posterior cardinal, so far as the writer's experience extends, one vessel is usually developed at the expense of the other. This idea is well borne out by a comparison of Figs. 1, 3, and 4.

In the type of abnormality represented by Fig. 1, the "Connecting branch" is absent, and the left posterior cardinal persists as far forward as the kidneys.

In Fig. 3 the left posterior cardinal is likewise persistent as far forward as the kidneys, but the "Connecting branch," though present, collects little, if any, of the blood from the left hind extremity.

In Fig. 4 both vessels persist, but the left posterior cardinal is insignificant, while the "Connecting branch" is normal in every respect, and undoubtedly, on account of its large relative size, is the chief collector of the blood from the left hind extremity.

¹ In the preparation represented by Fig. 4 the common internal iliac artery (10) is unusually long. Compare with corresponding arteries in Figs. 1, 3, 6.

The middle sacral vein and the "Connecting branch" (*V. iliaca communis sinistra*) must be developed in close relation with each other, since the former normally opens into the latter. It

is not strange, therefore, in one instance (Fig. 3) where the "Connecting branch" is abnormal, that it should arise from the middle sacral vein.

2. ON THE PRESENCE OF UNUSUALLY LONG COMMON ILIAC

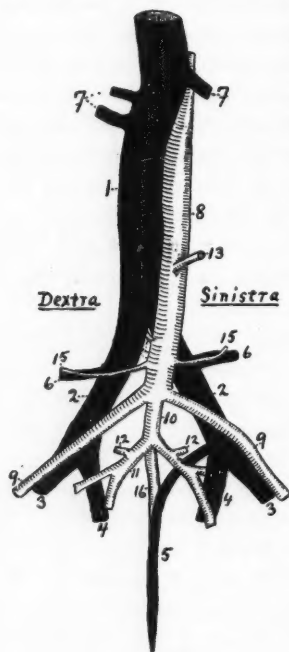


FIG. 6.

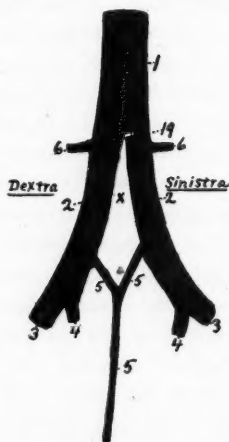


FIG. 7.

FIG. 6. — Princeton Morphological Museum, No. 604. Unusually long *Vv. iliaca communes* which unite with postcava opposite the middle of the sixth lumbar vertebra. Ventral aspect. 2. *V. iliaca communis*. 13. *A. mesenterica post.* For remaining numbers, see Fig. 1.

FIG. 7. — Princeton Morphological Museum, No. 605. Same as Fig. 6. Ventral aspect. Arteries omitted in the drawing. 19. *A. lumbalis*. X. Opposite origin of *Aa. iliaca externae* from aorta. For remaining numbers, see Fig. 1.

VEINS (*Vv. iliaca communes*). — The point at which the single postcava joins the right and left common iliac veins is normally, with slight variations, opposite the middle of the seventh lumbar vertebra. In three cats, not including those which possessed well-defined double postcaval veins, the point of union of the two common iliacs with the common postcava was found to be opposite the middle of the sixth lumbar vertebra,

which is considerably cephalad of the normal point, and to result in relatively long common iliac veins (2), Figs. 6, 7.

The writer was at first inclined to regard these three cases as instances in which the posterior division of the left posterior cardinal vein, instead of the "Connecting branch," persists as the functional left common iliac vein, and for the following reasons:

1. Because in one instance (Fig. 7) the middle sacral vein (5) opens into the angle of union of two veins, as in those cases in which both posterior cardinal veins persist (Fig. 1).

2. Because the left ilio-lumbar vein (6), in all three cases, opens into the left common iliac (2) and not into the common postcava (1), as is normally the case in the cat. (See Figs. 6, 7.)

3. Because the functional left common iliac vein (2), in all three cases, unites with the corresponding vein of the opposite side in front of the middle of the sixth lumbar vertebra and, in this respect, resembles the left posterior cardinal vein (17) in Fig. 4, which persists there, in addition to a left common iliac vein ("Connecting branch"). In other words, if the left common iliac vein (2) were absent in Fig. 4, the latter would resemble, so far as the veins are concerned, the conditions met with in Fig. 6.

One marked difference exists, however, between the relative position of the left common iliac (2) in the three cases cited above and that of the left posterior cardinal vein (17) in Fig. 4. In the latter the vein lies ventrad of the aorta, the position it should normally assume were the vessel a persistent cardinal vein. In the three other cases, of which Fig. 6 is an example, the aorta (8) lies ventrad of the vein, which should not be its position unless a transposition of the vessel has taken place, a circumstance incapable of proof. Whatever the significance of this abnormality may be, it is certainly worthy of mention, for it further emphasizes the fact that variations of the postcaval vein and its tributaries are of unusual frequency in the cat.

3. THE MIDDLE SACRAL VEIN (*V. sacralis media*) AND ITS RELATIONS TO THE VEINS OF THE PELVIC REGION. — Much has already been said concerning this vein, but its variations are so pronounced, that it seems best to specify them more in detail.

The middle sacral vein usually opens into the left common iliac, and this was found to be the case by the writer in 60 per cent of the cats examined. In some instances this vein (5) was found to open into the left common iliac (2), near the point of union of the external and internal iliac veins (3 and 4), Fig. 6.

In other instances its connection with the left common iliac was somewhat cephalad of this point.

In four cats, or 16 per cent of those examined, the middle sacral vein (5) opened into the right common iliac (2), Fig. 8. This was the case with one of those preparations in which the common iliac veins were unusually long and joined the single postcava opposite the sixth lumbar vertebra.

In five cats, or 20 per cent of those examined, the middle sacral vein (5) opened into the angle of union of two veins which joined a vein of the right and left side, respectively (Figs. 1, 3, 7).

4. ON THE PRESENCE OF FORAMINA IN VEINS THROUGH WHICH ARTERIES AND NERVES PASS. — (a) Six cases were met by the writer in which a vein presented a completely formed foramen through which an artery passed. In four of these cases the internal iliac artery passed through a foramen in the common iliac vein. In the two remaining instances a lumbar

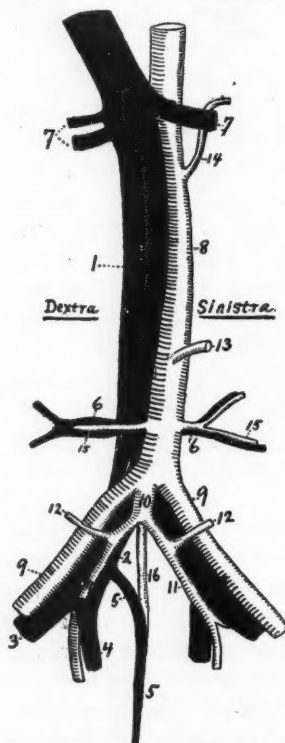


FIG. 8. — Princeton Morphological Museum, No. 606. Perforation of *V. iliaca communis dextra* by *A. iliaca interna dextra*. Ventral aspect. 2. *V. iliaca communis*. 13. *A. mesenterica post.* 14. *A. renalis*. For remaining numbers, see Fig. 1.

artery passed dorsad through a foramen in the postcaval vein.

Two cases were met with in which the right internal iliac artery (11) passed through a foramen in the right common iliac vein (2), as represented by Fig. 8.

The foramen, which, in both cases, was situated near the juncture of the external and internal iliac veins, was complete, so that the artery could be dissected away from the vein without injuring the latter. After passing through the foramen the artery naturally lies dorsad of the vein, but in its subsequent course assumes its usual position at the side of the vein.

Two cases were met with, in which the left internal iliac artery passed through a foramen in the left common iliac vein. Since there is no essential difference between any of these four cases, so far as the character and relative position of the foramina are concerned, Fig. 8 will serve as a description for all.

Treadwell¹ has described an abnormality as occurring in the cat somewhat similar to these four cases described above, but on account of the poor condition of his preparation, he was unable to locate accurately the exact position of the foramen.

An examination of his figure leads the writer to the conclusion that his preparation is similar, in every respect, to that represented above by my Fig. 8.

The two cases in which a lumbar artery passed through a foramen in the postcaval vein resemble those mentioned above, so far as the completeness of the foramina is concerned, and, therefore, need no further mention. It is interesting to note, however, that in each instance the vein was penetrated by the same lumbar artery, the artery situated just cephalad of the ilio-lumbar artery.

(b) Foramina, when present, were not exclusively connected with the transference of arteries. In three cats both obturator nerves (18), Fig. 5, were found to pass through foramina situated at the point where the external and internal iliac veins unite.

The foramina in each instance were complete, and, as in the case of the arteries, the nerves were easily dissected away without injuring the veins.²

¹ *Anat. Anz.*, Bd. xi, p. 717.

² Ogle (*Journ. of Anat. and Phys.*, vol. xxix) describes a case as occurring in man, in which the left hypoglossal nerve pierced the wall of the left vertebral artery.

It is well known that the perforation of a vein by an artery or nerve is not, by itself, of unusual occurrence, but that it should occur with such frequency in the domestic cat, and in connection with so many other abnormalities, is deemed by the writer as worthy of mention, as it further emphasizes the unstable condition of the veins in the lumbar and pelvic regions.

Whatever the cause may be which has produced this type of abnormality, it is probably the same for both nerve and artery, and, Treadwell says, "may be referred back to the origin of the vessels in the embryo, where an interference between the formative cells of the artery and those of the vein has resulted in a penetration of one by the other."

It seems worthy of emphasis to note, in this connection, that in each instance it is the vein which is perforated and never the artery.

5. DOUBLE VEINS WHERE ONE IS NORMALLY PRESENT. — This type of abnormality is, likewise, of fairly common occurrence, and is only mentioned to further emphasize the frequency of venous abnormalities in the regions in question.

In seven instances veins which are usually single were paired, and with one exception, Fig. 1 (left double ilio-lumbar veins, 6), this duplicity occurred in connection with the veins of the right side.

Four of the above-mentioned cases refer to the renal veins and three to the ilio-lumbar.

In one case, Fig. 8 (6), the right ilio-lumbar vein (*V. ilio-lumbalis dextra*) opened into the postcava (1) by two veins, but laterad of the postcava the two veins were fused together, and through the cleft thus formed the right ilio-lumbar artery (15) passed.

The question might be asked, — Is the manner in which this cleft is formed, in any sense, comparable with that of the foramina mentioned above in connection with the postcava and common iliac veins?

It seems probable to the writer, since the foramina in the common iliac veins are located near the point of union of two veins, that these foramina may have been formed as the result

of a secondary union of the veins behind the artery or nerve which passes between them.

As previously stated, the lumbar artery, which, in two cases, was found to penetrate the postcava, was the one situated just anterior to the ilio-lumbar veins. In the case represented by Fig. 7, this artery (19) lies between the common iliac veins, near their point of union. If in this instance the veins should fuse behind the artery, a foramen would be formed which resembles in every respect the two met with in the postcava.

So far as could be ascertained by the writer, the number of abnormalities of the arterial system, in general, was small. This was also the case with the veins of the neck and fore-limb regions, which in no way approximated those found in connection with the postcava and its tributaries.

The arterial abnormalities were chiefly confined to the ilio-lumbar and iliac arteries, an example of the latter being figured below (Fig. 9).

One conclusion which may be drawn from a perusal of the preceding pages is that, in the cat, the veins of the lumbar and pelvic regions appear to be more liable to variation than those of any other region of the body. Whether this variation may be the result, as some might maintain in virtue of the shifting character of the lumbar vertebra, of a general instability of this region is an open question.

The greater frequency, however, with which abnormalities of the postcava and its tributaries occur, whatever the causes may be which produce them, may possibly be explained on the following grounds: The veins of the lumbar and pelvic regions possess a marked primitive arrangement in the embryo, which differs from that of the adult. In the transition from the embryonic to the adult condition, the veins, on account of the changes which they have to undergo, thus readily lend themselves to variations when, for any cause, their normal development is interrupted.

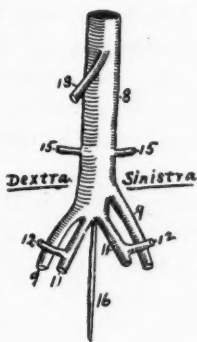


FIG. 9. — Princeton Morphological Museum, No. 607. Abnormal mode of origin of *Aa. iliaca*. Ventral aspect. 13. *A. mesenterica post.* For remaining numbers, see Fig. 1.

It is without the purpose of this paper to discuss the causes which are responsible for the production of venous abnormalities. It seems fair to assume, however, that any cause which may disturb the character of the normal stimuli that control the development of an organism may correspondingly influence the veins, by either arresting, accelerating, or even annulling their development.

Such causes, the effects of which undoubtedly influence these normal stimuli, must be numerous, and among others the following might be mentioned: Domestication, inbreeding, disease, drugs, and shock.

It seems, therefore, reasonable to assume that breeding experiments, carried out on these lines, might give us some clue as to the direct causes, as well as the relation of cause and effect, which are responsible for the production of abnormalities of the vascular system.

PRINCETON, N. J., January, 1900.

THE NORTH-AMERICAN JUMPING MICE.

J. A. ALLEN.

THE jumping mice of North America form a peculiar group, restricted, with one exception, so far as now known, to the middle and northern parts of North America, ranging from North Carolina, Missouri, New Mexico, and central California, northward to Labrador, Great Slave Lake, and the Yukon River. They are a little larger than the common house mouse, with very long hind legs and a very long tail. They are yellowish brown above and white below, the color of the dorsal and ventral areas being sharply separated by a broad lateral line of bright yellowish orange. They generally prefer moist meadows, marshy thickets, and the edge of woodland, but some species frequent deep forests, near streams. They are thus necessarily local in distribution, and not generally abundant, and being apparently nocturnal in habits are not often met with. They also pass the severer parts of the winter in hibernation. Opinion seems to be divided in reference to whether they constitute a distinct family type, or merely form a well-marked subfamily of the Old World Dipodidæ, or Jerboas, with which they were formerly associated generically by early writers, and of which they may be considered the American representatives. They were first generically separated from the Old World Jerboas by Coues in 1875, under the name *Zapus*, which he considered to represent also a distinct family, *Zapodidæ*.

The members of this genus greatly resemble each other in size and color; so much so that, with the scanty and imperfect material then available for study, Baird, in 1857, and Coues, in 1877, recognized only a single species. A second was made known by Miller in 1891, and a third by Allen in 1893, while during the following six years some twenty additional species and subspecies were added. Mr. Edward A. Preble, assistant in the United States Biological Survey, has recently made a

revision of the group,¹ recognizing three subgenera, twelve species, and nine additional subspecies, of which two subgenera, three species, and five subspecies are characterized as new. One of the species, and the only non-American species known, is the *Zapus setchuanus*, from Szechuen, China, the type and sole representative of Preble's new subgenus, *Eozapus*. The molar pattern, as figured by Preble, is, however, so different in this type from that of the American forms of *Zapus* that it seems well entitled to full generic rank. The twenty American forms are separated into two subgenera, *Zapus* proper and *Napæozapus*, the latter differing from the former mainly in the absence of the minute upper premolar always found in *Zapus*. *Napæozapus* comprises the single species, *Z. insignis*, described by Miller in 1891, with its subspecies *abietorum* and *roanensis*. The *Z. insignis* group, characterized among other features by a white-tipped tail, in contrast with the species of *Zapus*, is an Eastern type, described originally from New Brunswick, and since found to range southward, in the Canadian fauna, to the mountains of North Carolina, where it forms Mr. Preble's subspecies *roanensis*, and westward to the north shore of Lake Superior, where it constitutes the same author's subspecies *abietorum*.

These subtractions leave seventeen forms — ten species and seven subspecies — in the restricted subgenus *Zapus*, which collectively cover the whole of the North American range of the genus *Zapus*, the subgenus *Zapus* being found throughout the range of *Napæozapus* as well as elsewhere.

As already said, only one species, *Zapus hudsonius*, was recognized prior to the description of *Z. insignis* Miller in 1891, but of course many other forms were confounded under this name; but even now in its restricted sense, or as defined by Preble, it has, including its four well-marked subspecies, by far the most extensive range of any member of the genus, being found from the southern shore of Hudson Bay southward to New Jersey and in the mountains to North Carolina, and westward to Iowa and Alaska.

¹ Preble, Edward A., assistant in Biological Survey. Revision of the Jumping Mice of the Genus *Zapus*, *North American Fauna*, No. 15, Aug. 8, 1899, pp. 1-41, 1 plate and 3 text-figures.

Mr. Preble, in this revision of the group, has done a good piece of work in seemingly a very acceptable manner, he having had at his command practically all of the material available in our museums and private collections, including the types of all of the recently described forms, the specimens examined by him numbering nearly one thousand.

Of the thirty specific and subspecific names applied to members of this group, seven of the nine synonyms are referred to the long known *Zapus hudsonius*. A list of the species and subspecies recognized by Mr. Preble here follows, with a brief statement of their ranges, so far as known, based on Mr. Preble's excellent paper. Much still remains to be learned about the group, especially in respect to the geographical distribution of most of the forms, but a good foundation has been laid on which to build the final superstructure.

SUBGENUS ZAPUS.

1. *Zapus hudsonius* (Zimmermann). Type locality, Hudson Bay. From Hudson Bay south to New Jersey and in the mountains to North Carolina; west to Iowa and Great Slave Lake. (Includes *Z. h. canadensis* Batchelder and *Z. h. hardyi* Batchelder.)

1 a. *Zapus hudsonius ladas* Bangs. Eastern Quebec, north to Hamilton Inlet, Labrador.

1 b. *Zapus hudsonius americanus* (Barton). Vicinity of Raleigh, N. C., north along the coastal plain to southern Connecticut and the lower Hudson valley.

1 c. *Zapus hudsonius campestris* Preble. Great Plains, from Manitoba to Nebraska, and northeastern Colorado, west over eastern Wyoming.

1 d. *Zapus hudsonius alascensis* Merriam. Yakutat Bay, north to Yukon River.

2. *Zapus tenellus* Merriam. Known only from vicinity of Kamloops, B. C.

3. *Zapus princeps* Allen. Rocky Mountain region, from New Mexico to northern Alberta.

3 a. *Zapus princeps minor* Preble. Plains of Saskatchewan.

3 b. *Zapus princeps oregonus* Preble. Blue Mountains of Oregon.

4. *Zapus major* Preble. Known only from the type, from Warner Mountains, Oregon.

5. *Zapus nevadensis* Preble. Known only from the type, taken in the Ruby Mountains, Nevada.

6. *Zapus trinotatus* Rhoads. Coast region, from Frazer River, B. C., to northern California. (Includes *Z. imperator* Elliot.)

6 a. *Zapus trinotatus alleni* Elliot. Mount Shasta and Sierra Nevada of California.

7. *Zapus montanus* Merriam. Cascade Range, Oregon.

8. *Zapus orarius* Preble. Coast of California from Point Reyes to Mendocino County.

9. *Zapus pacificus* Merriam. Rogue River Valley, Oregon, and southward into California.

10. *Zapus saltator* Allen. Northern British Columbia.

SUBGENUS NAPÆOZAPUS.

11. *Zapus insignis* Miller. New Brunswick, northern New England, Adirondacks and Catskills of New York, and southward in the Alleghanies to Maryland.

11 a. *Zapus insignis roanensis* Preble. Roan Mountains, N. C.

11 b. *Zapus insignis abietorum* Preble. Quebec and western Ontario.

FRESH-WATER AQUARIA.

L. MURBACH.

THE lover of nature, taking his early spring walks, often feels the desire to cultivate a nearer acquaintance with the living things that he sees in ponds and pools along his way. He may dip up samples here and there, taking some water weed and a string of the jelly beads containing toads' eggs, place them in glass jars or aquaria at home, and gain further pleasure, for a few days at most, and then the whole mass becomes foul and is thrown away. His ill-success is due to the improper balance between animals and to the popular misconception that an aquarium with animal life should be uncovered so that the animals can get air to breathe; and the remedy lies in keeping the aquarium, once properly balanced from one spring to another, so well covered that scarcely any evaporation of water can take place. To this then may be added new organisms from time to time.

None of the numerous notices on the keeping of aquaria that I have seen describe permanent aquaria without changing the water; yet this is one of the most desirable features—to keep the aquarium, year in year out, for observing the interesting succession of forms, often including representatives of animal groups from Protozoa to Crustacea, with an almost equal diversity of aquatic plants.

Some of the pond scum (algæ), drawn by light and adhering to the side of the glass, may be made to decorate the side of the aquarium with almost any pattern in green—letters, or your monogram if you choose. Some of my experience may be useful to the reader, and I gladly give it for what it may be worth.

Seeing the algæ in my largest aquarium accumulate on the side most strongly lighted, it occurred to me that they might be made to form a definite design by regulating the light.

First a stencil of paper or pasteboard was used, but as this was not permanent enough, one of my students, living next door to a tinsmith, cut out the monogram of our school and attached it to the outside of the aquarium, having previously cleaned the inside with a scraper. In a few weeks the letters "D. H. S." were sharply marked by the sun's ray-pencils and the microscopic green plants within. (See figure in *Journ. Applied Micros.*, July, 1899, Vol. II, No. 7.) The stencil may be removed at any time for inspection, but should be kept in position the half of each day, while the strongest light falls on the aquarium to keep the letters from being obliterated. This experiment serves to illustrate the movement of green plants towards the source of light, and has interested many of our visitors.

Such balanced aquaria also have a practical value in the schoolroom or laboratory; each one will have its own fauna, and may serve as a source of animalculæ — Amœbæ and other Protozoa so highly prized by the young teacher — and larger animals and plants for demonstration, experiment or research, in more nearly their natural environment, than those kept in water changed daily. This last spring we had a nice illustration of this fact; some fairy shrimps (*Branchipus*) were placed in a glass jar with water and plants of their habitat, and a few were placed in one of the balanced aquaria of the same size and receiving the same lighting. Those in the first jar died in a few days (the common experience of every one who has tried to keep them in the laboratory for demonstration), while those in the aquarium lived three times longer.

In one small aquarium jar, set up over a year ago, containing mostly diatoms, *Oscillaria*, some water fleas and Rotatoria, there has been a good supply of Amœbæ for class use. Another larger one, kept over two and one half years, in which a large snail, some water weed, and smaller animals constitute the balance, furnishes sun animalcules for demonstration. The largest one, with glass plate sides, slate bottom and ends, has been kept nearly two years without change or addition of water. It is stocked with aquatic plants, *Cladophora*, *Myriophyllum*, *Lemna*, *Wolffia*, *Anacharis*, and many single-celled algæ. The

largest animal representative is a so-called "bull-head" (one of the species of *Uranidæ*), about four inches long, kept principally for the balance, and because he needs no further attention than a few earthworms every few days. In this aquarium fresh-water polyps, *Polyzoa*, and other interesting forms appear in their season.

In speaking of the time these aquaria have been kept, it is to be understood without changing the water but covered in such a way as to require very little or no additions of water to supply evaporation.

The aëration of the water for the breathing of animals will be readily seen to come from the oxygen given out by the plants while they feed (during photo-syntax) on the carbonic acid gas given out by the animals. The only thing needing attention is the feeding of such animals as cannot find their source of food in the aquaria themselves, and this should be done so carefully that no food is left to decay.

For aquaria almost any kind of glass vessel that can be securely covered against dust and bacteria may be used—jam jars, battery jars, culture dishes and globes for the smaller window aquaria; window glass, properly cemented into wooden frames that are kept coated with paraffin or asphalt varnish, for a medium size; and slate bottom and ends, with plate-glass sides, for the larger though more expensive ones.

In setting up the aquaria it is better to begin with water from some clean pond containing considerable plant and animal life. Fill up to within a few inches of the top with water, and then add about $\frac{1}{25}$ its bulk of plants and animals; or hydrant water may be used, adding some plants, and later the animals desired. Where there is no choice, snails and *Crustaceæ* are the most convenient for use, unless they are hostile to the organisms desired for experiment. The snails feed on the plants, giving these carbonic acid in turn for food, while the *Crustaceæ* feed mostly on the débris from other organisms.

If the animals keep near the surface, too many are probably present, and some must be removed or more plants added. When the plants become yellow they are too abundant or have not had light enough. In some cases the water becomes foul

on first setting up the aquarium, and as this is one way of obtaining certain desirable results, keep it covered until the foul odor disappears, and if new plants do not appear in time, add plants and animals to suit, and it may prove to be the best aquarium you have. Marine Protozoa have been kept this way in jars brought from the seashore several years ago.

CENTRAL HIGH SCHOOL,
DETROIT, MICH.

SYNOPSIS OF NORTH-AMERICAN INVERTEBRATES. VIII.

THE ISOPODA. — PART I.

CHELIFERA, FLABELLIFERA, VALVIFERA.

HARRIET RICHARDSON.

THE Isopoda represent an order of Crustacea widely distributed and varying greatly in their mode of life and in their habitat. They abound not only in the sea, where they are taken in shallow water and from the greatest depths, but large numbers of them are also found in ponds and streams and other bodies of fresh water. The terrestrial Isopoda form a large and important group, and are commonly known as "pill-bugs." Many of the Isopoda live a free existence, while others are parasitic. These latter are found in the mouths and gills of fishes, in the branchial cavities of Decapoda, on Copepoda, and on other Isopoda.

In the following key the marine forms have not been limited bathymetrically. Where it has been possible, the depth from which the specimens were taken has been given. The fresh-water and terrestrial forms are included.

The lettering for the distribution of species has been adopted in accordance with what has been used in former papers of this series of synopses on marine invertebrates: *A* for Alaska south; *P* for Puget Sound to San Francisco; *D* for Monterey to San Diego; *N*, Atlantic coast south to Cape Cod; *M*, Cape Cod to North Carolina; *S*, South Carolina to Florida; *G*, Gulf of Mexico.

The literature on the Isopoda has been limited in the following list to those papers which treat especially of North American forms. The most important of these are:

1817. SAY, THOMAS. An Account of the Crustacea of the United States. *Journ. Acad. Nat. Sci. Philadelphia.* Vol. i, pt. i, pp. 393-401, 423-433, 482-485.

1852. DANA, JAMES D. Crustacea of the United States Exploring Expedition. Vol. i, pp. 696-805.
1853. STIMPSON, WM. Synopsis of the Marine Invertebrata of Grand Manan, Smithsonian Contributions to Knowledge. Vol. vi.
1854. DANA, JAMES D. Catalogue and Descriptions of Crustacea collected in California by Dr. John Le Conte. *Proc. Acad. Nat. Sci. Philadelphia*. Vol. vii, pp. 175-177.
1857. STIMPSON, WM. Crustacea and Echinodermata of the Pacific Shores of North America. *Journ. Boston Soc. Nat. Hist.* Vol. vi.
1866. BATE, SPENCE. In Lord's "Naturalist in British Columbia." Pp. 281-284.
1874. VERRILL, A. E., and SMITH, S. I. Report upon the Invertebrate Animals of Vineyard Sound. *Rept. U. S. Fish Comm. for 1871-1872*.
1875. STUXBERG, A. Om Nord-Amerikas Oniscider. *Ofversigt af Vetensk. Akad. Forhandl.*, No. 2.
1877. HARFORD. Description of a New Genus and Three New Species of Sessile-Eyed Crustacea, pp. 54, 55, and Descriptions of Three New Species of Sessile-Eyed Crustacea, with Remarks on *Ligia occidentalis*, pp. 116, 117. *Proc. California Acad. Sci.* 1876. Vol. vii.
1877. LOCKINGTON, W. N. Remarks on the Crustacea of the Pacific Coast, with Descriptions of Some New Species, p. 36, and Descriptions of Seventeen New Species of Crustacea, pp. 44-46. *Proc. California Acad. Sci.* 1876. Vol. vii.
1880. HARGER, OSCAR. Report on the Marine Isopoda of New England and Adjacent Waters. *Rept. U. S. Fish Comm. for 1878*.
1883. HARGER, OSCAR. Reports on the Results of Dredging, under the Supervision of Alexander Agassiz, on the East Coast of the United States, during the Summer of 1880, by the U. S. Coast Survey Steamer *Blake*, Commander J. R. Bartlett, U. S. N., commanding. *Bull. Mus. Comp. Zool., Harvard College*. Vol. xi, No. 4, pt. xxiii.
1887. HANSEN, H. J. Oversigt over det vestlige Grønlands Fauna af Malakotrake Havkrebsdyr. *Vidensk. Meddel. fra den Naturh. Foren. i. Kjobh.* Pp. 177-198.
1897. BENEDICT, JAMES E. A Revision of the Genus *Synidotea*. *Proc. Acad. Nat. Sci. Philadelphia*. Pp. 389-404.
1898. BENEDICT, JAMES E. The *Arcturidæ* in the U. S. Nat. Museum. *Proc. Biol. Soc. Washington*. Vol. xii, pp. 41-51.
1898. BENEDICT, JAMES E. Two New Isopods of the Genus *Idotea* from the Coast of California. *Proc. Biol. Soc. Washington*. Vol. xii, pp. 53-55.
1898. WALKER, ALFRED O. Crustacea Collected by W. A. Herdman in Puget Sound, Pacific Coast of North America. *Trans. Liverpool Biol. Soc.* Vol. xii, pp. 279-281.

1898. CALMAN, W. T. On a Collection of Crustacea from Puget Sound. *Ann. New York Acad. Sci.* Vol. xi, No. 13, pp. 274-282.
1899. RICHARDSON, HARRIET. Key to the Isopods of the Pacific Coast of North America, with Descriptions of Twenty-two New Species. *Proc. U. S. Nat. Mus.* Vol. xxi, pp. 815-869.
1900. RICHARDSON, HARRIET. Key to the Isopoda of the Atlantic Coast of North America, with Descriptions of New Species. (In manuscript, to be published later.)

In addition to those mentioned, the works of G. O. Sars, H. J. Hansen, Schiøedte and Meinert, Stebbing and Budde-Lund, have been of much assistance in the compilation of this key.

SYNOPSIS OF THE ISOPODA.

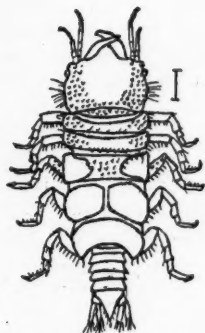
- a. Legs of the first pair cheliform. Uropoda terminal. Pleopoda, when distinctly developed, exclusively natatory. . . . I. CHELIFERA
- a'. Legs of the first pair not cheliform.
 - b. Uropoda lateral.
 - c. Uropoda forming together with the terminal segment of the abdomen a caudal fan. Pleopoda for the most part natatory. . . . II. FLABELLIFERA
 - c'. Uropoda valve-like, inflexed, arching over the pleopoda, which, to a great extent, are branchial. III. VALVIFERA
 - b'. Uropoda terminal.
 - c. Free forms.
 - d. Pleopoda exclusively branchial, generally covered by a thin opercular plate (the modified first pair).
 - IV. ASELOTA
 - d'. Pleopoda fitted for air-breathing. . V. ONISCOIDEA
 - c'. Parasitic forms. Pleopoda, when present, exclusively branchial in the adult form, and not covered by any operculum.
 - VI. EPICARIDEA

I. CHELIFERA.

- a. Body scarcely attenuated behind. Mandibles without palp. Anterior maxillæ with only a single masticatory lobe and a one-jointed palp; posterior ones quite rudimentary. Epignath of maxillipeds narrow, falciform. Superior antennæ with one multi-articulate flagellum. Second pair of legs ambulatory in character. . Family I. Tanaidæ
- a'. Body narrow, produced, depressed. Mandibles with a three-jointed palp. Anterior maxillæ with two masticatory lobes and a two-jointed palp; posterior ones well developed and setose. Epignath of maxillipeds large, laminar, branchial in character. Superior antennæ with two multi-articulate flagella. Second pair of legs with a large, broad, flat hand, for burrowing purposes. . Family II. Apseudidæ

FAMILY I. TANAIDÆ.

- a. Pleopoda only three pairs. Uropoda simple, short, single-branched.
Tanais Audouin and Edwards
 - α'. Pleopoda five pairs. Uropoda double-branched.
 - b. Eyes wanting.
 - c. Inner branch of uropoda two to three-jointed. Pleopoda in female very small or rudimentary.
 - d. Incubatory pouch formed only by two lamellæ issuing from bases of fourth pair of legs. Pleopoda in female rudimentary. Gnathopods alike in both-sexes. Mandibles well developed, with cutting edge coarsely dentated. Cryptocope G. O. Sars
 - d'. Incubatory pouch normal. Pleopoda in female small, sometimes wanting. Gnathopods in female of normal appearance, hand dilated, fingers strong, thumb serrulated, in male slender, fingers simple. Mandibles very small and feeble in structure, with cutting edge narrow. Leptognathia G. O. Sars
 - c'. Inner branch of uropoda eight to nine-jointed. Pleopoda well developed. . . Aloatanais Norman and Stebbing
 - β. Eyes present.
 - c. Gnathopods in male imperfectly chelate, without any finger, or with finger very short and immovable.
Heterotanaïs G. O. Sars
 - c'. Gnathopods in male with chelæ fully developed.
 - d. Gnathopods in male sometimes very much elongated, with carpus attenuated, hand very large, oblong, finger elongate and curved, immovable, strongly tuberculate within. Thoracic appendages not specialized into an anterior and a posterior series. Marsupium of female formed of eight large lamellæ from the four first free segments.
Leptochelia Dana
 - d'. Gnathopods in male with chelæ very stout, the distal section of the penultimate joint extremely broad, with a toothed margin. Thoracic appendages specialized into an anterior and a posterior series. Marsupium of the female of the normal structure.
Neotanaïs Beddard
- Genus Tanais Audouin and Edwards.
- a. Periopoda having the first three joints short and broad, dilated and affixed to the sides of the thorax like plates of mail.
Tanais loricatus Spence Bate, A, 10 fms.
 - α'. Periopoda, with joints not dilated, slender.

FIG. 1.—*Tanais alascensis*.FIG. 2.¹—*Gnathia cerina*.FIG. 3.¹—*Cyathura carinata*.

b. Abdomen composed of six segments. Body robust and tapering.
Tanais robustus Moore, *M*

b'. Abdomen composed of five distinct segments. Body slender, elongated.

c. With transverse setiferous bands crossing first and second abdominal segments. Terminal segment with a blunt median projection. Uropoda three-jointed.

Tanais cavolinii Milne Edwards, *N*

c'. Without transverse setiferous bands crossing first and second abdominal segments. Terminal segment with slight median notch. Uropoda seven-jointed.

Tanais alascensis Richardson, *A*, 6–8 fms.

Genus *Cryptocope* G. O. Sars. . *Cryptocope arctica* Hansen, *N*, 170 fms.

Genus *Leptognathia* G. O. Sars.

a. In female inner branch of uropoda twice as long as outer. The second or first free segment of thorax is about two-thirds as long as the third, which in turn is about equal to the fourth and fifth. Sixth and seventh segments are progressively somewhat shorter. Propodus of first pair of legs less robust than carpus.

Leptognathia caeca (Harger), *N*, surface to 48 fms.

a'. In female inner branch of uropoda more than three times as long as outer. The second, or first free segment of thorax about same size as the last one, both being shorter than the others. Propodus of first pair of legs scarcely smaller than carpus.

Leptognathia longiremus (Lilljeborg), *N*, 35–40 fms.

¹ Figures taken from O. Harger.

Genus *Aloatanais* Norman and Stebbing.

Aloatanais hastiger Norman and Stebbing, *N*, 1750 fms.

Genus *Heterotanaïs* G. O. Sars. *Heterotanaïs limnicola* Harger, *N*, 48 fms.

Genus *Leptochelia* Dana.

a. Gnathopods in male greatly elongated, with tuberculate immobile finger.

Upper antennæ three-jointed, with rudimentary flagellum in female, much more elongated, and with a multi-articulate flagellum in male.

b. Inner branch of uropoda five-jointed. Antennulæ, with basal segment nearly one-half length of the whole organ, are more than one-third as long as the body.

Leptochelia rapax Harger, *N*, one-half fm.

b'. Inner branch of uropoda six-jointed. Antennulæ, with basal segment about one-third length of the whole organ, are about two-thirds as long as body.

Leptochelia savignyi (Krøyer), *N*, surface

a'. Gnathopods in male not greatly elongated. Upper antennæ three-jointed, not elongated in male.

b. Inner branch of the uropoda five-jointed. Terminal abdominal segment rounded behind.

Leptochelia (?) *filum* (Stimpson), *N*, 8 fms.

b'. Inner branch of the uropoda six-jointed. Terminal abdominal segment pointed posteriorly.

Leptochelia dubia (Krøyer), *N*, surface to one-half fm.

Genus *Neotanaïs* Beddard. *Neotanaïs americanus* Beddard, *M*, 1240 fms.

FAMILY II. APSEUDIDÆ.

a. Lower antennæ with a scale articulated to the end of the second joint. First free segment of the thorax with epimera conspicuous, spine-formed, porrected. First five pair of pleopoda with both branches usually one-jointed. Exopods on both pairs of gnathopods.

Apseudes Leach

a'. Lower antennæ without a scale. Carapace composed of head and two following segments coalesced. Sphyrapus Norman and Stebbing

Genus *Apseudes* Leach.

Apseudes gracilis Norman and Stebbing, *N*, 1750 fms.

Genus *Sphyrapus* Norman and Stebbing.

Sphyrapus malleolus Norman and Stebbing, *N*, 1450 fms.

II. FLABELLIFERA.

a. Legs in the adult in six, apparently only in five pairs.

Family III. Gnathiida

a'. Legs in the adult in seven pairs.

- b. Uropoda lateral and superior, outer branch arching over base of telson. Body cylindrical, narrow, elongated.

Family IV. Anthuridae

- b. Uropoda lateral.

- c. Abdomen consisting of six segments.

- d. Uropoda with both branches developed; mostly lamelliform.

- e. Maxillipeds with the palp free, the margins of the last two joints more or less setose, never furnished with hooks.

- f. Mandibles with the distal half stout, very conspicuous, uncovered, or with only the anterior margin concealed; from the base towards the middle directed forwards and a little outwards.

- g. Mandibles with the rather broad, more or less tridentate, cutting edges meeting squarely behind the large upper lip; the secondary plate and peculiar equivalent for the molar well developed. First maxillæ having the plate of the first joint armed with three spines, that of the third with many. Second maxillæ of moderate size, the three free plates very setose. Maxillipeds with the palp rather broad, very setose.

Family V. Cirolanidae

- g'. Mandibles with the distal part produced into a long prominent process, the pair much overlapping; the secondary plate and molar evanescent. First maxillæ having the plate of the first joint unarmed, of the third, carrying one very long spine. Second maxillæ small and feeble, the free plates almost rudimentary, with few setæ. Maxillipeds with the palp narrowed, not very setose.

Family VI. Corallanidae

- f. Mandibles with the distal half narrow, most or all of it concealed by the upper and lower lips; from the base towards the apex directed gradually inwards.

Family VII. Alcironidae

- e. Maxillipeds with the palp embracing the cone formed by the distal parts of the mouth organs,

the inner upper margin and apex never setose, the apex and sometimes the inner upper margin, at least in the males and females without eggs, being furnished with outward curved hooks.

f. Mandibles with the secondary plate very often visible; palp with no inflated joint. Maxillipeds commonly seven-jointed, sometimes four-jointed, the last joint in the latter case rather short, obtuse. Antennæ long, unequal, with well-defined peduncle and flagellum. . . . Family VIII. *Ægidæ*

f'. Mandibles with no secondary plate; the palp in adults with first joint or both first and second joints inflated. Maxillipeds always four-jointed, last joint rather long and narrow, subacute. Antennæ much reduced without clear distinction between peduncle and flagellum. Family IX. *Cymothoidæ*

d'. Uropoda with one of the branches almost obsolete or rudimentary — not lamelliform.

Family X. *Limnoriidæ*

c'. Abdomen consisting of less than six segments.

d. Abdomen with two segments. Uropoda with one branch fixed, immovable. Family XI. *Sphæromidæ*

d'. Abdomen with four segments. Uropoda with both branches movable. . . . Family XII. *Serolidæ*

FAMILY III. GNATHIIDÆ.

Genus *Gnathia* Leach.

a. Mandibles in male with the basal part ornamented on the superior margin with an elevated crest, which is irregularly dentate. Legs furnished with many spiny processes. *Gnathia cristata* (Hansen), *N*, 116 fms.

a'. Mandibles in male without elevated crest on the superior margin. Legs without spiny processes.

b. Mandibles in male with slight notch outside, inner edge obtusely produced in the middle, tip acute, slightly incurved. Front of head not produced in the middle beyond the antero-lateral angles. . . . *Gnathia elongata* (Krøyer), *N*

b'. Mandibles in male carinate on outer side near the middle, the carina ending in a tooth-like process, irregularly and bluntly toothed near the base within, turned upward at apex. Front of head produced in the middle much beyond the antero-lateral angles.

Gnathia cerina (Stimpson), *N*, 10–220 fms. (See Fig. 2, p. 211.)

FAMILY IV. ANTHURIDÆ.

a. Labium terminating in two rounded lobes. Mandibles with cutting edge of two or three blunt teeth, and a semicircular saw in place of molar and spine row; palp three-jointed. First maxillæ simple, with apical teeth. Maxillipeds with three to six broad, flattened joints.

b. First five segments of the abdomen coalesced into a single segment in the female.

c. Maxillipeds three-jointed. Flagella of both pairs of antennæ few jointed in female; of first multi-articulate in male.

Anthura Leach

c. Maxillipeds four-jointed. Flagella of both pairs of antennæ rudimentary, of the first pair not greatly developed in the male. Cyathura Norman and Stebbing

b. Segments of abdomen distinct. Maxillipeds six-jointed.

Anthelura Norman and Stebbing

a. Labium terminating in two points, acuminate. Mandibles without teeth, lancet-like, lobes at base forming channel. First maxillæ spear-like, distally channeled and serrate. Maxillipeds elongate, with four to five joints, the second of which is elongate. Abdomen with six segments and caudal segment distinct. Antennæ in both sexes with many jointed flagella. Calathura Norman and Stebbing

Genus Anthura Leach. *Anthura tenuis* (Harger), *N*, surface to 19 fms.

Genus Cyathura Norman and Stebbing.

Cyathura carinata (Krøyer), *NM*, surface to 19½ fms. (See Fig. 3, p. 211.)

Genus Anthelura Norman and Stebbing.

Anthelura abyssorum Norman and Stebbing, *N*, 1750 fms.

Genus Calathura Norman and Stebbing.

Calathura branchiata (Stimpson), *N*, 20-200 fms.

FAMILY V. CIROLANIDÆ.

a. Peduncle of the second antennæ five-jointed. Plate of the second joint of the maxillipeds furnished with hooks.

b. Eyes present. Uropoda with the inner angle of the peduncle produced.

c. First and second pairs of pleopoda equal in length, with at least the inner branch submembranaceous.

Cirolana Leach

c. First pair of pleopoda with both branches hard, and forming a large operculum. Second pair of pleopoda submembranaceous. Conilera Leach

b. Eyes wanting. Uropoda with the inner angle of the peduncle not produced. Cirolanides Benedict

- a'*. Peduncle of second antennæ four-jointed. Plate of second joint of maxillipeds without hooks. Uropoda with inner angle of peduncle very little produced. Pleopoda with both branches submembranaceous. Superior antennæ with first joint of peduncle quite short, and extended straight in front at a right angle to remaining part of the antenna. Eurydice Leach

Genus *Cirolana* Leach.

- a*. Fifth abdominal segment with lateral angles free, not covered by the fourth segment. . . . *Cirolana linguifrons* Richardson, *D*, surface
- a'*. Fifth abdominal segment with lateral angles covered by fourth segment.

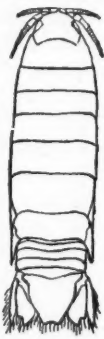


FIG. 4.¹—*Cirolana concharum*.

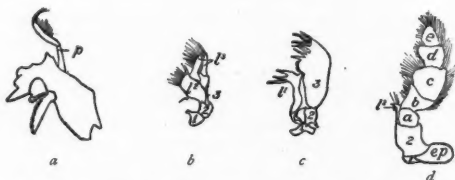


FIG. 5.¹—*a*, Mandible of *Cirolana borealis*; *p*, palp. *b*, Maxilla of the second pair; *1*, first joint; *2*, second joint; *12*, lobe of the second joint; *3*, third joint; *13*, lobes of the third joint. *c*, Maxilla of the first pair; *1*, first joint; *11*, lobe of the first joint; *2*, second joint; *3*, third joint. *d*, Maxilliped; *1*, first joint; *ep*, epignath; *2*, second joint; *12*, lobe of the second joint; *a*, *b*, *c*, *d*, *e*, palp.

- b*. Frontal lamina posteriorly or clypeus anteriorly produced horn-like, especially so when seen from the side.

Cirolana virginiana Richardson, *M*, 81 fms.

- b'*. Frontal lamina and clypeus unarmed, not produced horn-like; anterior margin of the clypeus connected with the frontal lamina.

- c*. Frontal lamina narrow, elongate, four to six times longer than broad.

- d*. Extremity of exterior margin of inner branch of the uropoda emarginate.

- e*. Terminal segment emarginate at its extremity.

Cirolana concharum (Stimpson), *NM*, surface to 18 fms.

- e'*. Terminal segment not emarginate at its extremity.

Cirolana impressa Harger, *M*, 115–321 fms.

- d'*. Extremity of exterior margin of inner branch of the uropoda not emarginate.

- e*. Second pair of antennæ long, extending beyond the posterior margin of the third thoracic segment. *Cirolana borealis* Lilljeborg, *S*, 233 fms.

¹ Figures taken from Hansen.

- c'*. Second pair of antennæ short, reaching to the middle of the first thoracic segment.

Cirolana polita Harger, *N*, 17-190 fms.

- c*. Frontal lamina broad, short, scarcely twice as long as wide.

- d*. Terminal segment with the posterior margin armed with many (twenty-six) robust spines. Branches of uropoda with apex rounded.

Cirolana harfordi (Lockington), *APD*, surface to 40 fms.

- d'*. Terminal segment with the posterior margin armed with a few slender spines. Branches of uropoda with apex acute.

Cirolana parva Hansen, *G*, 25-27 fms.

Genus *Conilera* Leach.

Conilera cylindracea (Montague), *SG*, 111-159 fms.

Genus *Cirolanides* Benedict.

Cirolanides texensis Benedict, Texas, fresh-water

Genus *Eurydice* Leach.

- a*. Second pair of antennæ in male extend to the posterior margin of fourth abdominal segment; flagellum consists of twenty-five joints. Terminal segment truncate between the post-lateral teeth.

Eurydice caudata Richardson, *D*

- a'*. Second pair of antennæ in male extend the entire length of the body; flagellum consists of eighteen joints. Terminal segment rounded between the post-lateral teeth. . *Eurydice convexa* Richardson, *G*

FAMILY VI. CORALLANIDÆ.

Genus *Corallana* Dana. *Corallana truncata* Richardson, *D*

FAMILY VII. ALCIRONIDÆ.

Genus *Alcirona* Hansen. *Alcirona krebsii* Hansen, *G*, 25-28 fms.

FAMILY VIII. ÆGIDÆ.

- a*. Body rather compact. Superior antennæ short, with first two peduncular joints more or less expanded. Epistome large, linguiform, projecting between the bases of inferior antennæ. Maxillipeds with palp composed of five joints. Front separating the whole or a great part of the first article of the first pair of antennæ. Flagellum of the first pair of antennæ composed of many joints. Abdomen compact. *Æga* Leach
- a'*. Body depressed. Superior antennæ short, with basal joints not expanded. Epistome very small and narrow. Maxillipeds with palp composed of only two joints. Front covering more or less the

peduncle of the first pair of antennæ. Flagellum of first pair of antennæ composed of four to six joints. Abdomen relaxed.

- b.* Eyes present. Anterior pairs of legs with propodus more or less expanded, dactylus forming a very large and evenly curved hook. Mandibles with the cutting edge expanded inside to a linguiform lamella; palp well developed, with basal joint much elongated. Abdomen not much narrower than thorax.

Rocinela Leach

- b'.* Eyes wanting. Anterior pairs of legs with propodus not expanded, dactylus abruptly curved in the middle, and terminating in a very sharp point. Mandibles with the cutting edge simple, acuminate; palp of moderate length. Abdomen narrowing abruptly to a much smaller width than the thorax; terminal segment very large. Syscenus Harger

Genus *Æga* Leach.

- a.* Peduncle of the first pair of antennæ plane or concave, joints fitting into each other. Frontal lamina plane or concave.

- b.* Terminal segment of body pointed at extremity. Eyes distant.

Æga psora (Linn), *N*, 30-218 fms.

- b'.* Terminal segment of body not pointed at extremity.

- c.* Terminal segment posteriorly bisinuate. Surface of segment smooth, without carinæ.

Æga ecarinata Richardson, *G*, 88 fms.

- c'.* Terminal segment emarginate or truncate.

- d.* Terminal segment emarginate. Eyes distant.

Æga webbii Gúerin, *S*, 333 fms.

- d'.* Terminal segment truncate.

- e.* Eyes contiguous. Propodus of the posterior prehensile legs with a cultriform lamina.

Æga crenulata Lütken, *N*

- e'.* Eyes not contiguous. Propodus of posterior prehensile legs without cultriform lamina.

Æga lecontii (Dana), *D*

- a'.* Peduncle of the first pair of antennæ well rounded and with joints compressed. Frontal lamina convex or compressly elevated.

- b.* Eyes contiguous. Terminal segment incised.

Æga incisa Schiøedte and Meinert, *S*, 263-440 fms.

- b'.* Eyes not contiguous.

- c.* Terminal segment linguæ, incised posteriorly.

Æga arctica Lütken, *N*.

- c'.* Terminal segment triangular, entire.

- d.* Terminal segment, with apex rounded.

Æga microphthalmia Dana, *D*

- d'.* Terminal segment, with apex produced.

Æga ventrosa Sars, *N*, 120 fms.

Genus *Rocinela* Leach.

- a.* Eyes contiguous. Head produced into process in front.

Rocinela oculata Harger, *S*, 252 fms.

- a'.* Eyes not contiguous. Flagellum of second pair of antennæ with fourteen to sixteen joints.

- b.* Propodus of prehensile legs with two to four spines.

- c.* First thoracic segment with antero-lateral angles produced horn-like at sides of head. Frontal margin of head produced. . . . *Rocinela cornuta* Richardson, *A*, 625 fms.

- c'.* First thoracic segment normal. Frontal margin of head not produced.

- d.* Spots present on both sides of the fourth thoracic segment. *Rocinela maculata* Schiødtte and Meinert, *N*

- d'.* Spots wanting on fourth thoracic segment.

- e.* Spots present on fourth and fifth abdominal segment and base of terminal segment.

Rocinela bellicepts (Stimpson), *APD*, surface to 138 fms. (See Fig. 6, p. 221.)

- e'.* Spots wanting on fourth and fifth abdominal segments and base of terminal segment.

Rocinela americana Schiødtte and Meinert, *NM*, 85-157 fms.

- v.* Propodus of prehensile legs with five to six spines.

Rocinela laticauda Hansen, *APD*, 82-660 fms.

Genus *Syscenus* Harger. . . . *Syscenus infelix* Harger, *M*, 231-435 fms.

FAMILY IX. CYMOTHOIDEÆ.

- a.* Head not at all immersed or set in the first thoracic segment.

- b.* Uropoda and terminal segment ciliated. Eyes large, conspicuous.

Ægathoa Dana

- v.* Uropoda and terminal segment not ciliated. Eyes small.

- c.* Posterior angles of first thoracic segment prominent or produced, very often acute; posterior angles of the following segments increasing gradually in length, the first of these very often scarcely prominent, the posterior ones very often produced, abruptly longer than the first. Epimera of the first segments extending beyond the posterior angles of the segment; posterior ones produced, acute. *Nerocila* Leach

- c'.* Posterior angles of first six thoracic segments scarcely or not at all prominent; those of the seventh segment produced. Epimera of first segments very often almost or quite reaching, or not reaching by a short distance the posterior angle of the segment.

- d.* Body compact. Head not constricted. Uropoda very often more or less longer than terminal segment. Legs gradually increasing in length. *Anilocra* Leach

- d.* Body relaxed. Head constricted at the base. Uropoda much shorter than terminal segment. Legs gradually much longer successively; seventh pair abruptly very much so. Olencira Leach
- a'.* Head more or less immersed or set in the first thoracic segment.
- b.* First pair of antennæ contiguous at the base.
- c.* Epimera of the first pair with a carina produced in the form of a spoon. Ungulæ very long, unequal in length; those of the third pair longest, abruptly longer than second pair. Terminal segment transverse. . . . Ceratothoa Dana
- c'.* Epimera of the first pair not produced. Ungulæ mostly very short, very rarely long, equal in length. Terminal segment subtriangular, semicircular, often bilobed.
- Meinertia Stebbing
- b'.* First pair of antennæ manifestly distant at the base.
- c.* Abdomen manifestly separated from the thorax, abruptly narrower than thorax. . . . Cymothoa Fabricius
- c'.* Abdomen contiguous with thorax, not narrower than thorax.
- Livoneca Leach

Genus *Ægathoa* Dana.

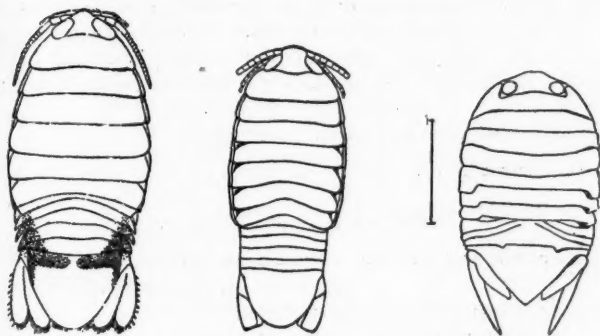
- a.* Surface of head smooth, evenly convex. Second pair of antennæ ten-jointed. First thoracic segment longer than any of the succeeding segments, which are of equal length.
- Ægathoa loliginea* Harger, *M*
- a'.* Surface of head with central portion sharply raised above the lateral portion, which is deeply excavate just in front of the eyes. Second pair of antennæ eight-jointed. First three thoracic segments subequal; last four subequal, and somewhat shorter than first three.

Ægathoa medialis Richardson, *M*, 3-25 fms.Genus *Nerocila* Leach.

- a.* Terminal segment regularly rounded. Head subtruncate in front. Eyes distinct, black. *Nerocila munda* Harger, *N*
- a'.* Terminal segment cordate, acuminate. Head rounded in front. Eyes indistinct, obscurely defined.
- b.* Uropoda scarcely longer than the apex of the terminal segment.
- Nerocila acuminata* Schiødt and Meinert, *GSM*
- b'.* Uropoda much longer than the apex of the terminal segment.

Nerocila californica Schiødt and Meinert, *D*Genus *Anilocra* Leach.

- a.* Terminal abdominal segment regularly rounded. All the epimera extend fully to the posterior angles of their corresponding segments. Branches of uropoda longer than terminal segment.
- Anilocra occidentalis* Richardson, *D*, 19 fms. (See Fig. 7, p. 221.)
- a'.* Terminal abdominal segment subcordate. Two first epimera reach the posterior angles of the segments; last four do not reach the angles

FIG. 6.—*Rocinela belliceps*. FIG. 7.—*Anilocra occidentalis*. FIG. 8.—*Tecticeps alascensis*.

of the segments. Branches of the uropoda much shorter than terminal segment. . . . *Anilocra laticauda* Milne Edwards, *MSG*
 Genus *Olencira* Leach. . . . *Olencira prægustator* (Latrobe), *MSG*
 Genus *Ceratothoa* Dana. . . . *Ceratothoa linearis* Dana, *M*
 Genus *Meinertia* Stebbing. *Meinertia transversa* Richardson, *G*, 347 fms.
 Genus *Cymothoa* Fabricius.

a. Terminal segment lanceolate. . . . *Cymothoa lanceolata* Say, *M*
a'. Terminal segment transverse; posterior margin widely sinuated or bilobed.

b. Anterior angles of the first thoracic segment short, acute; sides of the segment a little constricted. Inner branch of the uropoda much shorter than outer branch.

Cymothoa excisa Perty, *MSG*

b'. Anterior angles of the first thoracic segment very large, equaling or surpassing the front of the head, rounded. Sides of the segment flexuous. Inner branch of the uropoda manifestly longer than outer branch. . . *Cymothoa æstrum* (Linn), *M*

Genus *Livoneca* Leach.

a. Abdomen immersed in thorax, the sides of the first segment being almost entirely covered by the seventh thoracic segment.

b. Head narrowly rounded in front.

Livoneca californica Schiødtte and Meinert, *PD*

b'. Head broad, roundly truncate in front.

Livoneca vulgaris Stimpson, *D*

a'. Abdomen not immersed in thorax, the sides of the first segment free.

b. Uropoda much longer than caudal segment; inner branch narrow, obtuse, much shorter than outer branch. Epimera of last two thoracic segments not longer than segments.

Livoneca redmanni Leach, *SG*

- ♂. Uropoda hardly surpassing the caudal segment; both branches equal in length. Epimera of last two segments of thorax surpassing the segments. Head narrowly rounded in front. . . . *Livoneca ovalis* (Say), *NMSG*

FAMILY X. LIMNORIIDÆ.

Genus *Limnoria* Leach. . . . *Limnoria lignorum* (Rathke), *ANMS*

FAMILY XI. SPHÆROMIDÆ.

- a. Outer branch of the uropoda small, almost rudimentary.
Cassidena Milne Edwards

a'. Outer branch of the uropoda not rudimentary.

- b. Both external and internal branches of the uropoda projecting and exposed; outer branch capable of folding under inner.

c. Terminal segment of the abdomen entire.

- d. Margins of the head not produced. Antennæ conspicuous. Legs normal. Mandibles with a five-jointed palp. *Sphæroma* Latreille

d'. Anterior and lateral margins of the head produced, concealing the antennæ. Propodus of first and second pairs of legs dilated, with reflexed dactylus. Mandibles with a three-jointed palp. . . . *Tecticeps* Richardson

- c'. Terminal segment of the abdomen excavated at its extremity.
Dynamene Leach

♂. Only the external branch of the uropoda projecting and exposed; outer branch incapable of folding under inner.

- c. All the thoracic segments of equal length. Penultimate abdominal segment in male generally produced in spine. Terminal segment excavated with or without median lobe.
Cilicæa Leach

c'. Sixth segment of the thorax much enlarged, and produced at the center far backwards, covering the shorter seventh segment for the most part. Terminal segment excavate.
Næsa Leach

Genus *Cassidena* Milne Edwards. . . *Cassidena lunifrons* Richardson, *M*
Genus *Sphæroma* Latreille.

- a. Body widening gradually from head backwards. Thorax transversely ridged and provided with three longitudinal rows of small tubercles. Branches of the uropoda very large, expanded.

Sphæroma amplicauda Stimpson, *APD*, surface

a'. Body not increasing in width. Surface of thorax smooth. Branches of the uropoda not expanded.

- b. Extremity of terminal abdominal segment produced in a rhomboid process. *Sphæroma rhomburum* Richardson, *D*

V. Extremity of terminal abdominal segment not produced.

c. Surface of abdomen tubercular.

- d. Uropoda not reaching apex of terminal segment; outer branch the shorter and not denticulate. Terminal segment with eight tubercles.

Spharoma octoncum Richardson, D

- d'. Uropoda surpassing the apex of the terminal segment; outer branch the longer and provided with four teeth on external margin. Terminal segment with four tubercles.

Spharoma destructor Richardson, Florida fresh-water

c'. Surface of abdomen smooth.

- d. Outer branch of the uropoda denticulate on its external margin.

Spharoma quadridentatum Say, MS, surface to $\frac{1}{2}$ fm.

- d'. Outer branch of the uropoda not denticulate.

- e. Outer branch of the uropoda half as long as the inner branch, and half as wide.

Spharoma thermophilum Richardson, New Mexico, fresh-water

- e'. Outer branch of the uropoda not much shorter than inner branch, and of equal width.

Spharoma oregonensis Dana, APD, surface to 12 fms.

Genus Tecticeps Richardson.

- a. Terminal segment of abdomen pointed. Outer branch of uropoda much longer than inner branch. First pair of antennæ reach the posterior angle of the first thoracic segment. Second pair reach the middle of the second thoracic segment. Sixth and seventh pair of legs show a marked disproportion in the length of the propodus.

Tecticeps alascensis Richardson, A, 9-106 fms. (See Fig. 8, p. 221.)

- a'. Terminal segment of abdomen widely rounded. Outer branch of uropoda not longer than inner branch. First pair of antennæ reach the posterior angle of the third thoracic segment. Second pair of antennæ reach the middle of the fourth thoracic segment. Sixth and seventh pairs of legs show only a gradual increase in length.

Tecticeps convexus Richardson, D, 5 fms.

Genus Dynamene Leach.

- a. Frontal margin of head produced in a quadrangular process; first two joints of the first pair of antennæ dilated.

Dynamene dilalata Richardson, D, surface

- a'. Frontal margin of head not produced; joints of first pair of antennæ not dilated.

- b. Abdomen tuberculated. Neither branch of the uropoda reaching the extremity of the abdomen.

Dynamene tuberculosa Richardson, AD, surface

b. Abdomen not tuberculated. Inner branch of the uropoda reaching the extremity of the abdomen.

c. Ultimate segment of the abdomen ridged. Branches of uropoda of equal length. Sinus at extremity of abdomen funnel-shaped.

Dynamene benedicti Richardson, *D*, surface

c'. Ultimate segment of abdomen smooth. Outer branch of uropoda but little more than half as long as inner branch. Sinus at extremity of abdomen small.

Dynamene glabra Richardson, *D*, surface

Genus *Cilicæa* Leach.

a. Terminal segment with three sinuses, one above another in a longitudinal series, the two upper openings heart-shaped. Outer branch of the uropoda armed with four spines.

Cilicæa cordata Richardson, *A*, surface

a'. Terminal segment with one sinus. Outer branch of the uropoda unarmed.

b. Sinus without teeth. *Cilicæa carinata* Richardson, *S*, 440 fms.

b'. Sinus with teeth.

c. Sinus with four teeth. Median tubercle at base of terminal segment single. . . . *Cilicæa caudata* (Say), *M*, surface

c'. Sinus with six teeth. Median tubercle at base of terminal segment double.

Cilicæa caudata gilliana Richardson, *D*

Genus *Næsa* Leach. *Næsa* (?) *depressa* Say, *M*, surface

Næsa (?) *ovalis* Say, *S*, surface

FAMILY XII. SEROLIDÆ.

Genus *Serolis* Leach.

Serolis carinata Lockington, *D*, 3 fms. (See Fig. 9, p. 225.)

III. VALVIFERA.

a. Body more or less broad, depressed. Legs usually nearly alike, but first three pairs sometimes with propodus dilated and dactylus reflexed.

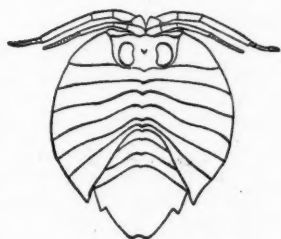
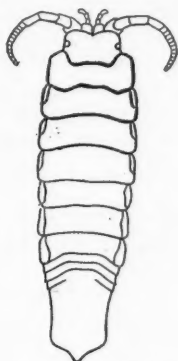
Family XIII. Idoteidæ

a'. Body narrow, scarcely depressed. Four anterior pairs of legs unlike three posterior pairs, and not ambulatory, nor strictly prehensile, directed forward, slender, ciliated, with terminal joint minute; last three pairs stouter, ambulatory, with terminal joint bifid.

Family XIV. Arcturidæ

FAMILY XIII. IDOTEIDÆ.

a. Sides of head emarginate or cleft and laterally produced beyond the eyes, which are situated upon its dorsal surface. Three anterior

FIG. 9. — *Serolis carinata*.FIG. 10. — *Idotea ochotensis*.

pairs of legs, with penultimate joint or propodus dilated, and forming, with reflexible dactylus, a prehensile hand. All the epimera distinct.

Chiridotea Harger

- a.* Sides of head entire and not laterally produced. Eyes lateral. Legs all ambulatory; three anterior pairs with penultimate joint not or not much dilated.

- b.* Flagellum of second pair of antennæ well developed and multi-articulate.

- c.* Palpus of maxillipeds four-jointed. Epimera of all the segments well developed and evident in a dorsal view. Abdomen (including the terminal segment) consisting of three segments with lateral sutures, indicative of another partly coalescent segment. *Idotea* Fabricius

- c.* Palpus of maxillipeds not four-jointed. Abdomen consisting of one segment, uniarticulate.

- d.* Palpus of maxillipeds three-jointed. All the epimera coalesced and perfectly united with the segments.

Synidotea Harger

- d.* Palpus of maxillipeds two-jointed. Epimera of second, third, and fourth segments coalesced and perfectly united with the segments; those of the fifth, sixth, and seventh segments distinct and well developed.

Colidotea Richardson

- b.* Flagellum of second pair of antennæ not multi-articulate.

- c.* Flagellum of second pair of antennæ rudimentary. Second pair of antennæ a little longer than first pair.

Edotea Guérin-Ménéville

- c.* Flagellum of second pair of antennæ usually obsolete. Second pair of antennæ much longer than first pair.

- d.* Legs subequal. Antennæ geniculate. Palp of maxillipeds four-jointed. Body angulate.

Erichsonella Benedict

- d'.* Third and fourth pairs of legs usually markedly shorter. Fifth, sixth, and seventh pairs gradually increasing in length. Antennæ not geniculate. Palp of maxillipeds two-jointed. Body slender, linear, smooth.

Cleantis Dana

Genus *Chiridotea* Harger.

- a.* Species large, elongate-ovate. Outer branch of uropoda (or opercular valves) minute.

- b.* Joints of the peduncle of the antennæ not dilated; flagellum eight to fourteen-jointed. Antero-lateral cervical lobes prominent. . . *Chiridotea entomon* (Linn.), *AP*, surface to 15 fms.

- b'.* Joints of the peduncle of the antennæ greatly dilated; flagellum seven to eight-jointed. Antero-cervical lobes prominent.

Chiridotea sabinii (Krøyer), *AN*, surface to 15 fms.

- a'.* Species small, orbiculate-ovate. Outer branch of uropoda at least half as long as inner.

- b.* Antennæ little longer than antennulæ; flagellum seven-jointed. Eyes inconspicuous. Antennulæ longer than the peduncle of the antennæ. . . . *Chiridotea cæcas* (Say), *NMS*, surface

- b'.* Antennæ twice as long as antennulæ; flagellum twelve-jointed. Eyes usually distinct. Antennulæ do not surpass the peduncle of the antennæ.

Chiridotea tuftsii (Stimpson), *NM*, surface to 25 fms.

Genus *Idotea* Fabricius.

- a.* Terminal segment emarginate at its extremity.

Idotea resecata Stimpson; *AD*, surface

- a'.* Terminal segment not emarginate at its extremity.

- b.* Body slender, linear, filiform.

- c.* Terminal segment truncate at apex.

Idotea gracillima Dana, *D*

- c'.* Terminal segment not truncate at its extremity.

- d.* Post-lateral angles of terminal segment prominent and separated by a tooth from subtriangular middle portion, which bears a small tooth at the middle.

Idotea urotoma Stimpson, *P*

- d'.* Post-lateral angles not separated by a tooth from middle portion.

Idotea rectilineata Lockington, *D*, 30-40 fms.

- b'.* Body oblong-ovate.

- c.* Terminal segment truncate at its extremity.

Idotea metallica Bosc, *NM*, surface 91 fms.

- c'.* Terminal segment not truncate.

- d. Terminal segment regularly and broadly rounded at its extremity, with small median tooth.

Idotea wosnesenskii Brandt, *APD*, surface to 9 fms.

- d'. Terminal segment acute or distinctly toothed at its extremity.

- e. With prominent post-lateral angles or teeth on either side of median tooth.

- f. With acute lateral teeth.

Idotea marina (Linn.), *NM*, surface to 119 fms.

- f'. With rounded lateral lobes.

- g. Epimera of second, third, and fourth segments short, not reaching the post-lateral angles of their respective segments.

Idotea ochotensis Brandt, *A*, surface to 18 fms. (See Fig. 10, p. 225.)

- g'. Epimera of all the segments reaching the post-lateral angles of their respective segments.

- h. Sides of thorax arcuate.

Idotea stenops Benedict, *D*

- h'. Sides of thorax more nearly parallel.

Idotea whitei Stimpson, *PD*

- e'. With sides sloping regularly to produced extremity.

Idotea phosphorea Harger, *N*, surface to 18 fms.

Genus *Synidotea* Harger.

- a. Terminal abdominal segment emarginate or notched at its extremity.

- b. Two spines or tubercles overhanging the frontal notch.

- c. Spines united near the base.

Synidotea pallida Benedict, *A*, 695 fms.

- c'. Spines free at base.

Synidotea erosa Benedict, *A*, 483 fms.

- b'. No spines or tubercles overhanging the frontal notch.

- c. With a low ridge arising between the eyes and interrupted on the median line.

- d. Outlines of abdomen subparallel.

Synidotea nebulosa Benedict, *A*, 9-32 fms.

- d'. Outlines of abdomen strongly arcuate.

Synidotea angulata Benedict, *AP*, 31-38 fms.

- c'. Without a ridge between the eyes.

- d. Outline of abdomen subtriangular.

- e. Front not excavated.

Synidotea consolidata (Stimpson), *P*

- e'. Front excavated.

- f. Outlines of thorax subparallel.

Synidotea marmorata (Packard), *N*, 36-129 fms.

f. Outlines of thorax strongly arcuate.

Synidotea bicuspidata (Owen), *AN*, 5-13½ fms.

d. Outlines of abdomen rounded.

Synidotea laticauda Benedict, *A*, surface to 56 fms.

a. Terminal abdominal segment pointed at its extremity.

b. Undulations of body not tubercular or spiny.

c. Tubercle in front of eyes not margined.

Synidotea nodulosa (Krøyer), *AN*, 16-119 fms.

c. Tubercle on the frontal margin and forming a part of it.

Synidotea laevis Benedict, *A*, 29-36 fms.

b. Undulations of the body tubercular and spiny.

c. Four spines on the front of the head; body spinous.

Synidotea muricata (Harford), *A*, 25 fms.

c. A wedge-shaped tubercle behind the frontal notch; body tubercular. . . . *Synidotea picta* Benedict, *A*, 9 fms.

Genus *Colidotea* Richardson *Colidotea rostrata* (Benedict), *P*

Genus *Edotea* Guérin-Ménéville.

a. Anterior angles of head produced into horn-like projections. Lateral angles of thoracic segments produced into horn-like projections. Four tubercles situated on dorsal surface of head.

Edotea acuta Richardson, *N*, 105 fms.

a. Anterior angles of head not produced into horn-like projections. Lateral angles of thoracic segments not produced into horn-like projections. Two tubercles situated on dorsal surface of head.

b. Lateral margins of thorax nearly even. Anterior angles of head not salient. Lateral margins of terminal segment scarcely indented.

Edotea triloba (Say), *NM*, surface to ½ fm.

b. Lateral margins of thorax angulated and salient. Anterior angles of head salient. Lateral margins of terminal segment indented; terminal segment rather elongated.

Edotea montosa (Stimpson), *NM*, 2-40 fms.

Genus *Erichsonella* Benedict.

a. Surface of body smooth throughout. Outline of body regular. Antennulae short. Terminal segment of body with but slight traces of a lateral tooth near its base on either side.

Erichsonella attenuata (Harger), *M*

a. Surface of body tuberculated. Outline of body serrate. Antennulae long. Terminal segment with a prominent lateral tooth near its base on either side. Large bifid tubercle on center of head. Median longitudinal row of tubercles on each thoracic segment.

Erichsonella filiformis (Say), *M*, 4½ to 7 fms.

Genus *Cleantis* Dana.

a. Flagellum consolidated and forming a single piece. Abdomen composed of four segments. Terminal abdominal segment with rounded

extremity; terminal portion of segment obliquely truncated, the oblique portion being surrounded by a raised margin.

Cleantis planicauda Benedict, *G*

- a*'. Flagellum composed of three joints. Abdomen composed of three segments. Terminal abdominal segment with acute post-lateral teeth on either side of rounded posterior portion. Surface of segment smooth throughout. *Cleantis heathii* Richardson, *D*

FAMILY XIV. ARCTURIDÆ.

- a*. Fourth segment of thorax not greatly longer than others. Marsupium of female composed of four pairs of plates. . . . *Arcturus* Latreille
- a*'. Fourth segment of thorax much longer than any of the others. Marsupium of female consisting of two plates affixed to this segment.

Astacilla Fleming

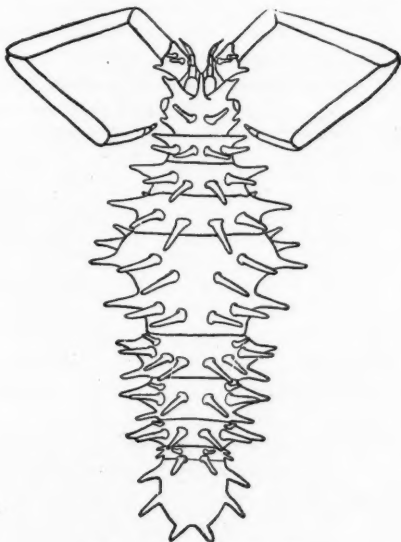


FIG. 11. — *Arcturus intermedius*.

Genus *Arcturus* Latreille.

- a*. End of terminal abdominal segment notched, as seen from above.
- b*. Body smooth and free from spines.

Arcturus beringanus Benedict, *A*, 29-36 fms.

- b*'. Body spiny.

- c*. Head and six segments of thorax, each with a pair of spines on the dorsum. Second and third articles of the antennæ without spines. *Arcturus longispinis* Benedict, *A*, 55 fms.

c. Head and segments of thorax with not less than two pairs of spines to the segment.

d. Head with one large median spine on the anterior part of the head in front of the eyes.

Arcturus intermedius Richardson, *A*, 10 fms. (See Fig. 11, p. 229.)

d'. Head with three spines on anterior part of head in front of eyes.

Arcturus murdochi Benedict, *A*, 13½ fms.

a'. End of terminal abdominal segment without notch.

b. Thorax without spines above the epimera.

Arcturus glaber Benedict, *A*, 55 fms.

b'. Thorax with spines above the epimera.

c. Terminal segment of abdomen armed with a long median terminal spine, projecting beyond the end of the segment.

Arcturus floridanus Richardson, *S*

c'. Terminal segment of abdomen not armed with long median terminal spine.

d. Four anterior segments of thorax with spines or tubercles. Middle surface of abdomen with prominent spiny projections. With conical lateral projections. Epimera pointed.

Arcturus baffini (Sabine), *N*, 110-150 fms.

d'. Four anterior segments of thorax without spines or tubercles. Middle surface of abdomen without any indication of prominent spiny projections. Without conical lateral projections. Epimera less pointed.

Arcturus feildeni Miers, *N*, 30 fms.

Genus *Astacilla* Fleming.

a. With eyes. Head excavate in front without rostriform point. Fourth thoracic segment subcylindrical. Terminal abdominal segment with a prominent, subacute tooth on each side, above the middle, directed outward and backward; extremity obtuse.

Astacilla granulata (G. O. Sars), *N*, 7-250 fms.

a'. Without eyes. Head with a rostriform point in front between the antennulæ. Fourth thoracic segment wider at the anterior end, and tapering to the posterior end. Terminal abdominal segment with a pair of teeth on each side; extremity acute.

Astacilla cæca Benedict, *N*, 1825 fms.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Payne's New World. — The second volume of this work, composed by an Oxfordian scholar, was published last year, and for its great intrinsic value deserves an extended notice; indeed there are but few historic works treating about this western continent that are written in a more careful and painstaking spirit. The full title is: *Edward John Payne, History of the New World, called America*, Vol. II. Oxford, at the Clarendon Press, 1899; octavo, pp. 27, 548. The volume begins with a sociological discussion on the pre-Columbian condition of the American tribes, their warrior and peasant classes, and the origin of the industrial class. Woman was the primitive laborer; she became enslaved by capture or by purchase, and the marriage question in the earliest epochs was nothing but a part of the problem of the food quest. The organization of the laboring class and the distribution of slaves and of land form another sociological chapter well worth studying. Then follows the discussion on the origin of the tribe, the horde, the family, the clan, the great house, together with the tribal migrations and the motives impelling peoples to migrate. The headings of subsequent sections of the work are as follows: Antiquity of Man in America; Ethnological Unity of the Aborigines; Origin and Process of Language; Material Aspect of Speech; Adaptation of Elementary Movements to Articulation; Mechanics of Language — Repetition; Original Aspects of Personality; Dynamics of the Holophrase; Differentiation of the Noun and Verb; Dispersonalization; Distinction of Number in Objects; Primitive Applications of Arithmetic; Calendars or Time-reckoning; Mexican Calendar; Spread of Man over the New World; History of the Nahuatlacâ (Mexicans); First Nahuatlacan Immigrants; Aculhuan Pueblos of the Plateau; The Valley of Mexico; The Aztecs; Peruvian Advancement.

To give our readers an idea how interestingly the material is handled by Payne, we transcribe what he says about agricultural communities, exclusively composed of women (pp. 10, 11), as have been discovered in many parts of the inhabited earth. "Such communities were formed, it would seem, by the same process of spon-

taneous emigration, derived their continuity from periodical visits, usually once a year and lasting for a month in the spring, by males from other tribes. Columbus, while coasting Haiti (1493), heard of such a community from an Indian who visited him on board the *Niña*. The account was precise; the women of 'Matinino' admitted annually, as temporary members of their tribe, a certain number of male visitors, who carried back with them, on departing, the male children born in each interval, the women retaining the girls to replenish their own society (Las Casas, *Historia*, Vol. I, p. 434). Later accounts afford a body of evidence strongly tending to prove the existence of such societies in the valley of the mighty stream on which these communities have indelibly stamped the name of River of Amazona. He who summarily rejects these accounts knows little of the realities of the transition from savagery to barbarism. Women, as the Spaniards often found to their cost, can use the bow and arrow not less effectively than men. In possession of this deadly weapon, as well as of the materials of subsistence, they might easily form independent communities, and maintain them by the means adopted by the South American Amazons for an indefinite period. When women, says Southey, have been accustomed to accompany their husbands to battle, there is nothing that can be thought improbable in their establishing themselves as an independent race and thus securing that freedom for their daughters which they had obtained for themselves."

It is important to notice that one-half at least of the volume treats of linguistics. The languages of the American natives are analyzed and, as to their mental capacities, compared with those of the Old World.

Some are possessed of highly polysynthetic features, whereas others have scarcely attained the lower degrees of agglutination. A few of their number may be called analytic, like those of the Maya family, but the majority are synthetic.

A. S. GATSCHET.

ZOOLOGY.

Koelliker's Reminiscences.—The reminiscences of a long life of interesting and worthy activity form the latest volume from Professor Koelliker.¹ The book contains a little over four hundred pages, of

¹ Koelliker, A. *Erinnerungen aus meinem Leben*. Leipzig, W. Engelmann. 1899. vi + 399 pp., 8 plates, and 10 text-figures.

which the first fifty are devoted to an autobiography, followed by something over a hundred on the author's scientific and other travels, and concluded by a résumé of his scientific work. There are numerous illustrations, including several portraits of the author.

Degeneration of Duodenal Glands in the Cat. — Stöhr¹ has recently shown that in fully grown cats single duodenal glands, or even parts of such glands, may completely degenerate; the degeneration begins with a thickening of the connective tissue surrounding the glands, followed by the death of the gland cells and their absorption by leucocytes.

P.

Greeley on Tide-Pool Fishes of California. — In the *Bulletin of the U. S. Fish Commission* for 1899 is a report by Arthur White Greeley, teacher of biology in the State Normal School of San Diego, on the fishes collected by him at the tide pools of California.

The small marine sculpins originally forming Girard's genus *Oligocottus* are here divided into seven genera: *Blennicottus* Gill, *Oxycottus* Jordan, *Rusciculus* Greeley, *Dialarchus* Greeley, *Oligocottus*, *Clinocottus* Gill and *Eximia* Greeley; and four new species, *Blennicottus recalvus*, *Rusciculus rimensis*, *Dialarchus snyderi*, and *Eximia rubellio*, are described and well figured. Greeley shows that the original types of *Blennicottus globiceps* and *Oligocottus maculosus* belonged to the northern forms, the species called *Blennicottus bryosus* and *Oligocottus borealis*, by Jordan and Evermann. This fact necessitates the new names of *Blennicottus recalvus* and *Dialarchus snyderi* for the species common to the southward of Monterey. The figure of *D. snyderi* is apparently taken from a female and fails to show the separation of the enlarged first anal ray on which the genus is based.

Mr. Greeley concludes from his study of intergrading forms that no real difference exists between the northern species of *Gibbonsia* (*evidens*) and the southern *Gibbonsia elegans*.

The pools of the rocky coasts of California, a region with high tides and a profuse growth of algæ, are especially rich in fish life. Those from Pescadero to Monterey have been very fully studied by Mr. Greeley, more carefully than by any one else. On the coast of Mexico the poisonous milky juice of the tree called Hava (contain-

¹ Stöhr, P. Ueber Rückbildung von Duodenaldrüsen, *Festschrift der phys.-med. Gesellschaft zu Würzburg*, pp. 209-214, 1 Taf., 1899.

ing strychnine) has been found very useful in killing the fishes of these pools, often not to be captured in any other way. Mr. Greeley found a good substitute for this poison in the commercial chloride of lime.

D. S. J.

Development of Brain Structures in Amia. — A. C. Eyclesheimer and B. M. Davis give in the *Journal of Comparative Neurology* a valuable study of "The Early Development of the Epiphysis and Paraphysis in Amia." The paper indicates that much is still to be known as to the origin of epiphysial outgrowths from brain structures.

D. S. J.

Scapanorhynchus and Mitsukurina. — In the *Annals and Magazine of Natural History*, Mr. A. S. Woodward, of the British Museum, has a note on *Mitsukurina owstoni* Jordan, an extraordinary lamnoid shark with a long flat blade on its snout, lately described from the deep waters of Japan.

Mr. Woodward shows that *Mitsukurina* is very closely related to the Cretaceous genus *Scapanorhynchus*, of which species are known from Mount Lebanon and from the chalk of England.

Mitsukurina and *Scapanorhynchus* agree in the elongate, blade-like snout, which is, however, longest in *Scapanorhynchus*. The skeleton, dentition, and gill openings seem to be similar in the two genera, and there appear to be no great differences in the fins. The dense shagreen is also similar in the two; the structure of the basal cartilages of the fins in *Scapanorhynchus* is unknown; nor is anything known of the claspers.

Mr. Woodward concludes that *Mitsukurina* is probably identical with his genus, *Scapanorhynchus*, this name being of prior date. On the other hand, it may be urged that this identity is not proved, and that the specific differences are considerable. There are great disadvantages in the identification of recent fishes with fossil genera which are more or less imperfectly known.

More complete knowledge of the extinct forms often shows that the recent species have undergone such differentiation as should constitute generic difference. I think it, therefore, better to retain for the recent shark the name *Mitsukurina*, although recognizing its close relationship to its Cretaceous homologue.

The family *Mitsukurinidæ* is supposed to differ from *Carchariidæ* (*Odontaspididæ*) in the presence of a *Polyodon*-like snout, and perhaps in the structure of its fins and claspers. The writer knows too

little of the fossil forms of this type to form a final opinion as to whether, in view of the relations of the fossil forms, the family Mitsukurinidæ can be maintained.

D. S. J.

The Lateral Line of the Toadfish.—Miss Cornelia M. Clapp, professor of zoölogy in Mount Holyoke College, presents as a doctor's thesis in the University of Chicago a careful study of "The Lateral Line System of *Batrachus tau*."

Dr. Clapp concludes that the lateral line represents an organ of special sense. "The ear seems like a connecting link between the system of lateral line organs from which it has probably originated and the most highly sensory structure in Vertebrata—the eye. Ayers has shown that the auditory organ is in reality a series of canal organs innervated by two distinct cranial nerves." It seems certain that a more thorough knowledge of the changes in these cutaneous sense organs found in fishes and in the embryonic stages of higher types is essential to the understanding of the nervous system itself as developed in higher forms.

It may be noticed that the proper name of our toadfish is *Opsanus tau*, not *Batrachus tau*. The name *Batrachus* was applied by Bloch and Schneider in 1801 to the scaly toadfishes of the tropics, which had still earlier received from Lacépède the name *Batrachoides*. The name is not, therefore, available for any other genus, and the second name in date, the first ever given to the type in question, must be chosen. This is Rafinesque's *Opsanus*.

D. S. J.

Greene on the Lateral Line of the California Toadfish.—In the *Journal of Morphology*, Dr. Charles Wilson Greene, of Stanford University, has an elaborate study of the complex lateral line of another species of toadfish, *Porichthys notatus*, of the California coast. This species has several lateral lines, each of the most complex character, far more specialized than in the common toadfish. The pores in the genus *Porichthys* are accompanied by round shining bodies resembling the luminous spots in certain deep-sea forms, as *Sternoptyx* and *Myctophum*. In *Porichthys* the shining bodies are not known to be self-luminous, and their origin is plainly in the lateral line. The other genera are not related to *Porichthys*, and in them the luminous spots are not outgrowths from the lateral canal system.

Dr. Greene makes no attempt to discuss the homology or significance of the lateral line. Too few forms have yet been studied to make such discussion conclusive. He gives a full account of the

anatomy of the shining bodies in Porichthys. He concludes that these are true phosphorescent organs.

Thus far no specimens have been found to be luminous in the aquarium, and light has not been developed through electric stimulation, or by excitement through ammonia.

D. S. J.

Absence of Retinal Pigment in the Dogfish.—In his study of the retina of the common dogfish (*Mustelus vulgaris*) Schaper¹ has made the noteworthy observation that the retinal pigment cells, which in most vertebrates are loaded with dark pigment granules, are in this animal absolutely devoid of such particles.

P.

Pupa-Grafting in Moths.—The method of grafting young animals, as devised by Born for tadpoles, has been applied by Crampton² to the pupæ of moths. An injured pupa at best regenerates sufficient integument to cover the wound. Parts of two longitudinally split pupæ joined in natural proportions failed to unite, but anterior and posterior portions cut at any level united. Compounds slightly smaller than normal or enlarged by the insertion of a ring failed to coalesce. Fragments grafted on whole pupæ formed exactly those portions they would have formed had they remained on the original pupa. Pupæ are easily united sidewise or endwise, but in these, as in all other cases, the union is that of the integument and superficial parts only. The results of these experiments on the colors of different species are especially interesting. When individuals of two species having different colors were united so that their hæmolymphs mingled, the outcome was almost always a double animal whose colors were normal. The same result was obtained from united males and females in species with differently colored sexes. The colors are probably produced, as a rule, through the action on the hæmolymph of a localized internal factor such as the "ferment" cytoplasm assumed by Mayer.

P.

Amitotic Followed by Mitotic Cell Division.—The observations of Gerassimoff, that cooling would convert the mitotic division of Spirogyra cells into amitotic, and of Pfeffer and Nathanson, that a

¹ Schaper, A. Die nervösen Elemente der Selachier-Retina in Methylenblaupräparaten, *Festschrift zum siebenzigsten Geburtstag von Carl von Kupffer*, 10 pp., 3 Taf. Jena, 1899.

² Crampton, H. E. An Experimental Study upon Lepidoptera, *Archiv für Entw.-mech.*, Bd. ix, pp. 293-318, Pls. XI-XIII, 1899.

temporary use of ether would call forth in the same plant a temporary amitotic division, led Häcker¹ to subject developing eggs to the action of ether to ascertain whether their mitotic division could be converted into a temporary amitotic one. The results of these experiments are that when the eggs of Cyclops are subjected to the action of five per cent ether for from two to three hours, they begin to divide by a process many steps of which have all the appearances of amitotic division, and that after being returned to fresh water they reassume normal mitotic division. Cells, then, after dividing by what to all appearances is amitosis, may return to mitosis. Till further study proves absolute identity the author prefers to call this induced amitosis *pseudoamitosis*.

P.

A New Unattached Hydroid.—In a paper on Woods Holl Hydroids, L. Murbach² redescibes *Corynitis Agassizii* and its medusa Gemmaria, and gives an account of a very remarkable unattached hydroid. It is represented by a single unbranched polyp of the Tubularian type with two circles of tentacles. A primitive perisarc envelops the hydrocaulus, at the end of which polyp buds are given off. Sexual reproduction takes place, the gonophores being between the two circles of tentacles. The polyp moves slowly from place to place and may be caught floating in quiet water. The author names it *Hypolytus peregrinus* and forestalls the systematic reviser by the statement: "Should the name here proposed for this new genus be preoccupied, I propose instead Gonohypolytus."

P.

Hydra Grafts.—The grafting of hydras has been studied by H. W. Rand.³ Lateral grafts do not persist as permanent abnormalities, but either constrict and separate from the stock or are resorbed by it. If the graft is large or has tentacles, it, as a rule, eventually separates from the stock; if it is small and without differentiated parts it may be resorbed. All the pieces that were resorbed were much larger than the minimum piece capable of regenerating if not employed as a graft. Lateral grafts differ from buds in that they do not separate from the stock as readily as buds do

¹ Häcker, V. Mitosen im Gefolge amitosen-ähnlicher Vorgänge, *Anat. Anzeiger*, Bd. xvii, pp. 9-20, 1900.

² Murbach, L. Hydroids from Woods Holl, Mass., *Quart. Journ. Micr. Sci.*, vol. xlii, pp. 341-360, Pl. 34, 1899.

³ Rand, H. W. The Regulation of Graft Abnormalities in Hydra, *Archiv für Entw.-mech.*, Bd. ix, pp. 161-214, Taf. V-VII, 1899.

from parents. The regulation of abnormalities in Hydra appears to be independent of external conditions, and seems to be rather an effect of certain qualities inherited by the organism. P.

Notes. — The third edition of Van Gehuchten's¹ well-known textbook on the nervous system of man has just been published. The work has been increased in bulk and now appears in two volumes of about six hundred pages each. The first volume contains a full account of the gross anatomy of the nervous system, the neurone, and the finer anatomy of the spinal cord; the second volume deals with the finer anatomy of the brain.

No. VII of Vol. III of the *American Journal of Physiology* contains the two following articles: "The Poisonous Character of a Pure NaCl Solution," by Jacques Loeb, and "Observations on the Degeneration and Regeneration of Motor and Sensory Nerve Endings in Voluntary Muscle," by G. C. Huber.

BOTANY.

Minnesota Plant Life.² — The broad scope of the botanical work that is being done in Minnesota by Professor MacMillan is evidenced by the present volume. *Minnesota Plant Life* is the third volume of the botanical series of the reports of the natural history survey of the state. Notwithstanding, the book is not only not at all technical in the accepted sense, but, in accordance with the avowed purpose of the author, it is presented in as untechnical and popular a form as possible. Every botanist is quite too familiar with the result of the usual popular presentation of any portion of the subject. Popular treatises on biological science, especially, have come to stand for everything that is loose in thought, inexact in treatment, and antique in doctrine. Matters have practically reached a point where no master in scientific thought will write a popular treatise, and where no mere dilettante is able to write a scientific one. Professor MacMillan's book is proof that it is possible to write popularly,

¹ Van Gehuchten, A. Anatomie du système nerveux de l'homme, tomes i, ii. Louvain, 1900.

² MacMillan, Conway, Professor of Botany in the University of Minnesota. St. Paul, *The Pioneer Press*, 1899. 8vo, xxv, 568 pp. Four plates and 240 illustrations.

i.e., untechnically, and at the same time in a genuinely scientific vein. While one may not agree at every point with the detail of the text, he is struck by the fact that there is here no loose statement and antiquated theory, while rare inexactitudes are to be explained by the difficulty of presenting in popular form, which is always quasi-didactic, matters upon which botanists themselves are not harmonious.

The tenor of the volume is indicated by the author's purpose to present the plant world as an assemblage of living things. This is accomplished by presenting the different taxonomic groups morphologically, by treating generally of structures and functions from an adaptational standpoint, and by pointing out the main biological facts in plant association. The first two chapters, which are in many respects the best, the most suggestive ones in the book, deal briefly but in a clear, elementary manner with distribution, zonation and migration. Considering its brevity, the question of zonation is especially well handled. An objection that might be brought against the treatment in certain places (pp. 5, 9, and elsewhere) is that it is quite too teleological. The allegorical method of statement is certainly the readiest, and, among scientists, it is perhaps as good as any. Taken in connection with the appalling literalness of beginners, it is unsafe, and invariably leads to confusion, if not to error, in the consideration of purpose and design.

Chapters III-XL, constituting much the larger part of the book, are concerned with a survey of the groups of plants from the slime moulds to the composites. The part dealing with the cryptogams is especially good, noticeably superior to the portion given over to the flowering plants. The latter is fluent and readable, but the structural standpoint is predominant to the exclusion of many matters of interest. The latter fact is probably to be explained by the need of keeping the size of the volume within reasonable limits. The author is certainly right in placing the consideration of structure before that of function and adaptation. Had it been possible, however, a modicum of the two would have increased the interest and the suggestiveness of this portion. The chapter upon the bacteria is a model of its kind. The freshness of the matter, taken with its concise thoroughness, will make it the most interesting and instructive part of the book, not only to those to whom the work is addressed, but to many botanists as well. In Chapter XX the author has not been so fortunate in his treatment of seeds and their production. No exception can be taken to the statement, but the exposition will doubtless produce confusion in the subject for those who come to it for the

first time. The same criticism holds elsewhere in the treatment of alternation of generations. Though both are confessedly stumbling-blocks for beginners, it seems certain that a development of these matters phylogenetically would have been more logical and more successful.

The consideration of adaptation to environment is comprehensive and replete with suggestions. Occasional inaccuracies creep in, and in a few instances doubtful or debatable explanations are presented as certain. The ecological factors considered are gravity, mechanical forces, heat, light, moisture, soil composition, and biological environment. Following this a chapter is given to the treatment of hydrophytes and one to xerophytes. Halophytes and mesophytes are also considered briefly. The treatment is good in the main, but in certain places it lacks coördination. This is doubtless due to lack of space, since the detail itself has apparently required pruning. The last two chapters deal with the intimate processes in the life of the individual and of the species. Protoplasm is treated of in a peculiarly striking and clear manner. Nutrition, growth, movement, protection likewise receive elementary treatment in simple logical fashion. The maintenance of the species, involving the phenomena and problems of propagation and reproduction, is clearly stated and is most suggestive.

Books, like people, are well dressed when the dress is not noticed. Until they attain this standard, however, it is a distinct pleasure to have to do with a book in so many ways faultless as the present one in the art of printer and engraver. When it is borne in mind that it belongs to the dubious class of "state-printed" books, it is at once seen how painstaking the author must have been to have produced a book of such uniform excellence of press-work and illustration.

It is novel and encouraging that a book of this sort should be published by the Board of Regents of a large university for the instruction of the people of the state. It is a distinct misfortune that the book is not on the market, as it should be found as a reference or reading book in all schools in which botany is taught.

FREDERIC E. CLEMENTS.

The Local Floras of New England. — In 1890 Dr. Britton published a list of state and local floras of the United States and British America, which has been of very great use to botanists working on the classification and distribution of our native plants. One hundred and six titles appear for the New England States. Miss

Mary A. Day, of the Gray Herbarium, has just distributed a pamphlet,¹ reprinted from Vol. I of *Rhodora*, in which 258 titles of books and papers referring to the flora of New England are cited, bringing the record down to the end of 1899. Miss Day's painstaking care, and the exceptional facilities afforded by the great libraries clustered about Boston and the interest in her work of the members of the New England Botanical Club, have resulted in the compilation of a bibliographic aid which should be in every botanical library in the country.

T.

Botanical Notes. — The *Tenth Annual Report* of the President of Columbia University states that the herbarium and the principal part of the botanical library of that institution have been transferred to the New York Botanical Garden, while for the future the advanced work in botany of the University will be carried on in the laboratories of the Garden. By this combination of the resources of the University with those of the Garden, the latter gains, it is stated, at the beginning of its career, a scientific equipment and a scientific importance which otherwise it could hope to achieve only slowly, while the University receives at once the advantage of the added facilities of the Garden, which, now considerable, will become of the greatest importance as the years go on. The Garden has inaugurated a new publication, under the title of *Journal*, which is intended to give popular information on the development and work of the establishment, and is to be edited by Dr. MacDougal.

The "Talcott Arboretum" of Mount Holyoke College, as appears from a recent number of *American Gardening*, is a glazed structure covering 6430 square feet and with a maximum height of 27 feet 9 inches.

The question of the classification of odors and their use in distinguishing things is again raised by W. C. Alpers in a paper on "Odor Standards," in the *Proceedings of the American Pharmaceutical Association*, Vol. XLVII, p. 221. He suggests a classification for the use of pharmacists, based on the chemical compounds which produce the odor sensations by reacting on the olfactory serum. Odor classifications, like that of Linnæus, and that of flower odors by Delpino, have their value at present, but rest on a more indefinite foundation than that proposed by Mr. Alpers. Kerner has given

¹ Day, M. A. *The Local Floras of New England*. 8vo, 28 pp. Cambridge, 1899. 35 cents.

such a preliminary classification of flower odors in his *Pflanzenleben*; but, as Mr. Alpers intimates, "a new field of research is spread before us for unlimited work" on the composition of volatile substances before a classification approaching perfection can be made.

J. B. S. NORTON.

Erythea, a wide-awake journal devoted largely to Western American botany, which has existed for seven years, is to be closed with the final part for 1899. It will be missed in many libraries, and yet the problem of the bibliographer will be simplified by a reduction in the number of journals that he must keep track of.

Part XXI of *Pittonia* for July to December, 1899, contains the following papers by Professor Greene: "A Decade of New Gutierrezias," "Some Western Species of Xanthium," "Four New Violets," "New or Noteworthy Species," XXV-XXVI, "Segregates of *Caltha leptosepala*," "New Species of *Arenaria*," and "West American *Asperifoliae*," IV.

Part III, second series, of *Minnesota Botanical Studies* contains two articles on algæ, two on lichens, and synonymic conspectuses of the native and garden Aconitums and Aquilegias of North America.

Cratægus, a genus in which species-splitting has heretofore been restricted to a rather remarkable degree, is proving to comprise a very large number of apparently separable forms as represented in North America, and Mr. C. D. Beadle, of the Biltmore estate, publishes in the *Botanical Gazette* for January a first instalment of studies in this genus, in which seven species are described as new. In fact, it appears as if almost anywhere in the middle South and West a half dozen nondescript red haws can be picked up in a day's botanizing, in their fruiting season, in autumn.

Mitella, of the trifida section, is passed in review by Piper in *Erythea* for December, with the result that four new species are described.

The Umbelliferae of Mexico and Central America are treated in an excellent paper by Coulter and Rose, issued in January as a brochure comprising pp. 111-159 of the first volume of the *Proceedings* of the Washington Academy of Sciences.

Rhodora for January contains an editorial note and a series of short articles on the dwarf mistletoe, *Arceuthobium pusillum*, in New England.

A systematic revision of the genus *Najas*, by A. B. Rendle, constitutes Vol. V, Part XII, of the current series of botanical *Transactions* of the Linnæan Society of London, issued in December.

A morphological and anatomical study of *Pogonia ophioglossoides* is published by Holm in the *American Journal of Science* for January.

Several new grasses from Pringle's Mexican collection of 1899 are described by Scribner in *Circular No. 19* of the Division of Agrostology of the United States Department of Agriculture.

Professor von Wettstein contributes a paper on the pistillate flower of Ginkgo to the December number of the *Oesterreichische Botanische Zeitschrift*, in which he regards the flower as an axillary bud with two transverse carpels.

Professor Thaxter, whose thorough work in the Laboulbeniaceæ has given him a most enviable reputation, publishes in a recent number of the *Proceedings* of the American Academy of Arts and Sciences diagnoses of a large number of new species of the typical genus *Laboulbenia*, preliminary to a supplement to his monograph of the order.

The subject of plants injurious to stock, on which considerable work has been done by American botanists, is further discussed by Mr. Carruthers, the consulting botanist of the Royal Agricultural Society of England, in No. 40 of the *Journal* of that society. A note by Dr. Labesse, in Vol. XVIII of the *Bulletin* of the Société d'études scientifiques d'Angers, shows that in France the tubers of *Enanthe crocata* are a source of considerable danger to stock.

Der Tropenpflanzer for January contains an interesting illustrated article by H. J. Boeken on the growth and preparation of fiber from *Agave sisalana*, in Yucatan.

The *Botanical Magazine* of Tokyo for December contains a portrait of the late Professor R. Yatabe. Professor Yatabe was trained at Cornell University, and was well known to many American students a quarter of a century ago, before returning to his native country, where he exerted an important influence in the development of the botanical work of the great Tokyo University.

A biographical sketch of H. G. Bloomer, with portrait, is published by Jepson in *Erythea* for December.

NEWS.

DR. ERNST EBROMAYER, professor of forestry in the University of Munich, has resigned.

The Supreme Court of Missouri has allowed the Shaw Botanical Gardens to sell a portion of their unproductive real estate. With the proceeds about twenty acres will be added to the gardens.

The Society of American Bacteriologists was organized at New Haven during Christmas week with a membership of over thirty. Professor W. T. Sedgwick was elected president, and Professor H. W. Conn, of Middletown, Conn., secretary for the coming year.

We hear from *Science* that the manuscript of a new edition of Coues's Key to North American Birds was left by the late Dr. Coues in a finished condition.

Appointments : Dr. Hugo Berger, professor of physiography in the University of Leipzig. — Dr. J. W. Gregory, of London, professor of geology in the University of Melbourne, Australia. — Dr. Hunnberg, privat docent for anatomy in the university at Giessen. — Dr. L. Hiltner, head of the bacteriological laboratory of the health office in Berlin. — Dr. E. Jacky, assistant in botany in Proskau. — W. L. Jepson, associate professor of botany in the University of California. — Dr. Itefan Jentys, professor of botany in the University of Agram. — Dr. J. C. Klinge, head botanist of the botanical gardens at St. Petersburg. — Mr. Frank Leney, of the British Museum, assistant curator of the museum at Norwich, England. — Dr. D. W. Merrill, assistant in biology in the University of Rochester. — Dr. Benjamin Lincoln Robinson, Gray professor of botany in Harvard University. — Dr. George Howard Parker, assistant professor of zoölogy in Harvard University. — Dr. G. Tanfiljen, head botanist in the botanical institute at St. Petersburg. — J. L. Luckett, demonstrator of physiology in the University of Cambridge. — Dr. Karl Wenle, docent for ethnology in the University of St. Petersburg.

Deaths : Count Wladimir Dzieduszycki, curator of the Lemburg Natural History Museum; in Galicia, September 19, aged 71. — Dr. Thomas Egleston, emeritus professor of mineralogy in Columbia University, in New York, January 15. — Dr. Henry Hicks, English geologist, November 18, aged 62. — Dr. Paul Knuth, professor of botany in the University of Kiel, October 30, aged 45. — William Pamplin, an English botanist, August 9, aged 92.

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